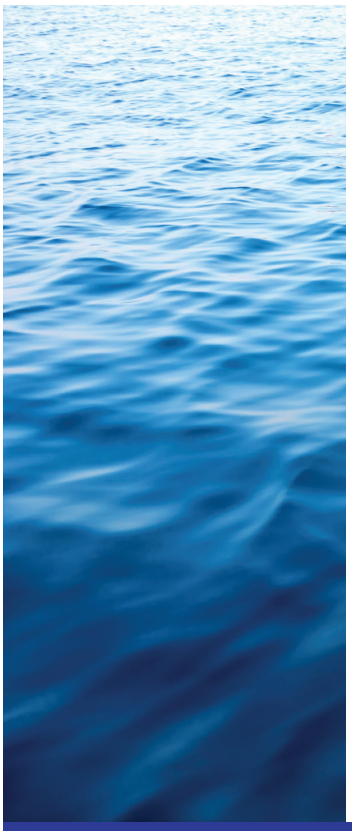

Environmental Impact Assessment

Yellowtail Development Project

Esso Exploration and Production Guyana Limited

Volume I

ERM

March 2022

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LIST OF ACRONYMS

Acronym	Definition
°	degree
°C	degrees Celsius
°F	degrees Fahrenheit
%	percent
µg/g	micrograms per gram
µg/L	micrograms per liter
µg/m^3	micrograms per cubic meter
µm	micrometer
µmol/kg	micromoles per kilogram
µPa	micro pascal
µSv/h	microSieverts per hour
3D	three dimensional
4D	four dimensional
AASM	Airgun Array Source Model
Act	Environmental Protection Act
AIDS	acquired immunodeficiency syndrome
AOI	Area of Influence
Application	Application for Environmental Authorisation
AQS	air quality standard
AUV	automated underwater vehicle
BAT	best available technology
bbl	barrel(s)
BETX	benzene, toulene, ethylbenzene, and xylenes
BOD_5	5-day biochemical oxygen demand
BOEM	Bureau of Ocean Energy Management (United States)
BOP	blowout preventer
BPD	barrels per day
BSEE	U.S. Bureau of Safety and Environmental Enforcement
CALM	catenary anchor leg mooring
CAPEX	capital expenditure
CARICOM	Caribbean Community
CARITRANS	Caribbean Transportation Consultancy Services Company Limited
C	Construction
CC	Community Council
CCR	central control room
CDC	Community Development Council
CEMCO	Caribbean Engineering & Management Consultants Inc.
CFU	Colony-forming Unit
CGM	Community Grievance Mechanism
CIA	cumulative impact assessment
CJIA	Cheddi Jagan International Airport
CLBD	Centre for Local Business Development
CLME	Caribbean Large Marine Ecosystem
cm	centimeter
cm/s	centimeter per second
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COD	chemical oxygen demand
Consultants	Environmental Resources Management (ERM), SLR Consulting (SLR), Caribbean Engineering & Management Consultants Inc. (CEMCO), The University of Guyana Centre for Study of Biological Diversity (CSBD), and Leon Moore Nature Experience (LMNE)
CORMIX	Cornell Mixing Zone Expert System
COVID-19	coronavirus disease 2019
CPI	Carbon preference index
CR	Critically Endangered (IUCN)
CSBD	University of Guyana Centre for Study of Biological Diversity
CSP	Construction Surveillance Plan
CTD	conductivity, temperature, and depth
CWMP	Comprehensive Waste Management Plan
dB	decibel
dBA	A-weighted decibel
DD	Data Deficient
DNA	deoxyribonucleic acid
DO	dissolved oxygen
DP	Dynamic Positioning
DWBC	Deep Western Boundary Current
EAB	Environmental Assessment Board
EAMP	Environmental Assessment and Management Plan
EBS	environmental baseline survey

Acronym	Definition
EBSA	Ecologically or Biologically Significant Area
ECIA	Eugene F. Correira International Airport
eDNA	environmental DNA
EEPGL	Esso Exploration and Production Guyana Limited
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EII	Eternity Investment Inc.
EIS	Environmental Impact Statement
EITI	Extractive Industries Transparency Initiative
EMP	environmental management plan
EN	Endangered (IUCN)
EPA	Guyana Environmental Protection Agency
ERL	Effect Range Low
ERM	Environmental Resources Management
ERM	Effects Range Median
ESMP	Environmental and Socioeconomic Management Plan
ESS	ecosystem services
ExxonMobil	Exxon Mobil Corporation
FLET	flowline end termination
FOC	fiber optic cable
FPSO	Floating Production, Storage, and Offloading (vessel)
FSO	Floating Storage and Offloading (vessel)
ft^2	square feet
FTU	Formazine Turbidity Unit
Fugro	Fugro Marine Geoservices, Inc.
FUND	International Fund for Compensation for Oil Pollution Damage, 1992
Fund	Natural Resource Fund
FWRAM	Full Waveform Range-dependent Acoustic Model
g	gravity
g/m^2	grams per square meter
GDP	gross domestic product
GEMSS	Generalized Environmental Modeling System for Surfacewaters
GGMC	Guyana Geology and Mines Commission
GHG	greenhouse gas
GLSC	Guyana Lands and Surveys and Land Commission
GMSA	Guyana Manufacturing and Services Association
GOC	Guyana Office Complex
GPS	global positioning system
GRIP	Global Rapid Intervention Package
GTE	Gas to Energy Project
GWI	Guyana Water Inc.
GYD	Guyanese dollar
GYSBI	Guyana Shore Base Inc.
H_2S	hydrogen sulfide
Handbook	Good Practice Handbook—Cumulative Impact Assessment and Management: Guidance for Private Sector in Emerging Markets
HBL	Haags Bosch Landfill
HIV	human immunodeficiency virus
HP	high pressure
HSF	hard seafloor feature
Hz	hertz
IBA	Important Bird Area
IBH	Important Bird Habitat
ICZM	Integrated Coastal Zone Management
IDB	Inter-American Development Bank
IFC	Internation Finance Corporation
ILO	International Labour Organization
IMO	International Maritime Organization
IOGP	International Oil and Gas Producers
IP	intermediate pressure
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
kHz	kilohertz
km	kilometer
km^2	square kilometer
LADCP	Lowered Acoustic Doppler Current Profiler
LC	Least Concern (IUCN)

Acronym	Definition
LCDS	Low Carbon Development Strategy
LDAR	leak detection and repair
L_{dn}	estimated day-night sound level
LFC	low-frequency cetacean
LME	Large Marine Ecosystem
LMNE	Leon Moore Nature Experience
LMP	Liquid Mud Plant
LOS	Level of Service
LP	low pressure
m	meter
m^2	square meter
m^3	cubic meter
m^3/d	cubic meters per day
MARAD	Maritime Administration Department
MARPOL 73/78	International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978
MBES	multi-beam echo sounder
MFC	Mid-frequency cetaceans
mg/L	milligrams per liter
MGO	marine gas oil
mi^2	square miles
MICS	Multiple Indicator Cluster Survey
MJ	megajoule
mL	milliliter
MLGRD	Ministry of Local Government and Regional Development
mm	millimeter
MMF	multi media filter
MMO	Marine Mammal Observer
MMscfd	million standard cubic feet per day
$MMsm^3/d$	million standard cubic meters per day
MOC	North Atlantic Meridional Overturning Circulation
MONM	Marine Operations Noise Model
MPa	megapascal
MPA	Marine Protected Area
MSV	marine support vessel
NA	not applicable
NAAQS	[U.S.] National Ambient Air Quality Standards
NABF	non-aqueous base fluid
NADF	non-aqueous drilling fluid
NBC	North Brazil Current
NBSAP	National Biodiversity Strategy and Action Plan
NDC	Neighbourhood Democratic Councils
NDS	National Development Strategy
NEAP	National Environmental Action Plan
NEBA	Net Environmental Benefit Analysis
NECC	North Equatorial Counter Current
ng/g	nanograms per gram
ng/L	nanograms per liter
NGL	natural gas liquid
NGO	non-governmental organization
NO_2	nitrogen dioxide
NOAA	U.S. National Oceanic and Atmospheric Administration
NORM	naturally occurring radioactive material
NOx	nitrogen oxides
NPD	naphthalene, phenanthrene, anthracene, and dibenzothiophene
NT	Near Threatened (IUCN)
NTU	Nephelometric Turbidity Unit
NW-NNW	northwest-north-northwest
OCIMF	Oil Companies International Marine Forum
OCM	Oil Content Monitor
ODU	optical distribution unit
OIMS	Operations Integrity Management System
OSPAR Convention	Convention for the Protection of the Marine Environment of the North-East Atlantic
OSRP	Oil Spill Response Plan
OWMS	Oilfield Waste Management Services
P&A	plugged and abandoned
PA	Petroleum Agreement
PAC	Project-Affected Communities
PAH	polycyclic aromatic hydrocarbons
PAM	passive acoustic monitoring
PBPA	Portland Bight Protected Area
PC	Project Contribution
PCS	Process Control System
PDA	Project Development Area
PEC	Predicted Environmental Concentration
PK	Peak Sound Pressure Level

Acronym	Definition
PM	particular matter
$PM_{2.5}$	particulate matter with aerodynamic diameter of less than 2.5 micrometers
PM_{10}	particulate matter with an aerodynamic diameter of less than 10 micrometers
ppb	parts per billion
ppb(v)	parts per billion by volume
PPE	personal protective equipment
ppm	parts per million
ppt	parts per thousand
Project	Yellowtail Development Project
PSC	Private Sector Commission
PSO	Protected Species Observer
PSP	Procurement Surveillance Plan
PSU	Practical Salinity Unit
PTS	Permanent Threshold Shift
PWRI	produced water reinjection
RDC	Regional Democratic Council
RMS	root mean square
ROV	remotely operated vehicle
SBPA	Shell Beach Protected Area
SDG	Sustainable Development Goal
SDU	Subsea Distribution Unit
SEL	sound exposure level
SEP	Stakeholder Engagement Plan
SES	Sustainable Environmental Solutions Guyana, Inc.
SGSCS	Suriname-Guyana Submarine Cable System
SHC	saturated and aliphatic hydrocarbons
SHPU	subsea hydraulic power unit
SIS	Safety Instrumented System
SLR	SLR Consulting
SO_2	sulfur dioxide
SOLAS	International Convention for the Safety of Life at Sea
sp.	species
SPL	sound pressure level
SPL_{rms}	root mean square sound pressure level
SQG	sediment quality guideline
SQuiRT	Screening Quick Reference Table
SRP	Sulfate Removal Package
SRU	Sulfate Removal Unit
SSH	sea surface height
SSS	side-scan sonar
STP	sewage treatment plant
SURF	Subsea, Umbilicals, Risers, and Flowlines
TB	tuberculosis
TBD	to be determined
TC	Town Council
TDS	total dissolved solids
TED	turtle excluder device
TEG	triethylene glycol
THC	total hydrocarbons
TOC	total organic carbon
ToR	Terms of Reference
TRG	Tiger Rentals Guyana Inc.
TSS	total suspended solids
TVET	Council for Technical and Vocational Education Training
UCM	Unresolved complex mixture
UF	ultrafiltration
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
USD	U.S. dollars
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VC	Village Council
VEC	Valued Environmental and Social Component
VOC	volatile organic compounds
VRU	Vapor Recovery Unit
VSP	Vertical Seismic Profile
VU	Vulnerable (IUCN)
WBDF	water-based drilling fluids
WCD	worst case discharge
WG2	Protected Species Observer
WHO	World Health Organization
WHRU	waste heat recovery unit
WRF	Weather Research and Forecasting
WRi	World Resources Institute
wt%	weight percent

GLOSSARY

This table lists key terms used in the Yellowtail Development Project Environmental Impact Assessment, including terms defined in the Environmental Protection Act 1996 (as amended in 2005) used in a manner consistent with the definitions provided in the Act. Any changes from the express definitions used in the Act have been made for clarity purposes only and are indicated by brackets.

Term	Definition
activity	Industrial or commercial activity or activity of any other nature whatsoever, and for those purposes the keeping of a substance is to be regarded as an activity.
adverse effect	• Impairment of the quality of the natural environment or any use that can be made of it • Injury or damage to property or to plant or animal life • Harm or material discomfort to any person • An adverse effect on the health of any person • Impairment of the safety of any person • Rendering any property or plant or animal life unfit for use by human or unfit for its role in its ecosystem • Loss of enjoyment of normal use of property • Interference with the normal conduct of business
agriculture	Includes horticulture, fruit growing, seed growing, dairy farming, fish farming, the breeding and keeping of livestock (including any animal kept for the production of foot, closing or for the purpose of farming of land), the use of land as grazing land, meadow land, market gardens and nursery grounds, the use of lands for woodlands where that is ancillary to the farming land for other purposes the harvesting and utilization of forest resources, and aquaculture.
ambient air quality standards	Limits that define the allowable concentration of a particular contaminant in a given area
anthropogenic	Made by humans or attributable to human activity.
Application	An Application for an Environmental Authorisation made in accordance with regulation 4.
barrel	The basic unit for measuring volume of oil or other liquids in the oil and gas industry. A barrel is equal to 42 U.S. gallons.
biogenic	Made by living organisms or attributable to the activity of living organisms.
biomagnification	Increasing concentration of a persistent substance, usually a pollutant or toxin, in the tissues of organisms at successively higher levels in a food chain.
borehole (or wellbore)	A deep hole drilled in the earth for the purpose of extracting a core, releasing gas, oil, water, etc.
casing	Steel pipe inserted into an oil or gas well to prevent the wall of the borehole from caving in, to prevent movement of fluids from one formation to another, and to improve the efficiency of extracting petroleum (for producing wells).
circumtropical	Distributed throughout the world's tropical latitudes.
commerce	Of or pertaining to business, trade, or manufacture.

Term	Definition
contaminant	Any solid, liquid, gas, odor, sound, vibration, radiation, heat, or combination of any of them resulting directly or indirectly from human activities that may cause an adverse effect.
congregatory	Tending to gather in large groups on a cyclical or otherwise regular and/or predictable basis.
crude oil	Liquid petroleum as it comes out of the ground. The properties of crude oil, such as color, gravity, and viscosity, can vary.
cumulative impact	Impacts that result from the successive, incremental, and/or combined effects of an action, project, or activity added to effects from other existing, planned, and/or reasonably certain actions, projects, or activities.
cuttings (or drill cuttings)	Broken bits of solid material produced as the drill bit advances through the borehole in the rock or soil. Cuttings are usually carried to the surface by the drilling fluid circulating up from the drill bit, and can be separated from the drilling fluid using a variety of treatment methods (e.g., centrifuge).
decibel	A unit, which describes the sound pressure level or intensity of sound.
developer	The applicant for environmental authorization for a project or the State initiating a project.
development well	A well drilled in a proven area in a field for the purposes of producing hydrocarbons.
discharge	The release of any liquid, solid or gaseous substance or a combination of them into the environment resulting directly or indirectly from human activities that may cause an adverse effect.
drill center	Defined as a group of wells (including production, water injection, and/or gas re-injection wells) clustered around one or more manifolds. Each drill center incorporates separate manifolds that are designed for production or injection.
drill ship	A self-propelled floating offshore drilling unit that is a ship constructed to allow a well to be drilled from it. Drill ships are generally the preferred option for drilling wells in deep, remote waters.
drilling fluids	Specially formulated fluids that are typically a mixture of barite, clay, water, and other chemical additives. Drilling fluids are circulated into the borehole to lubricate and cool the rotary drill bit, to lift the cuttings out of the borehole and to the surface, and to help maintain well control.
ecosystem services	The benefits that people obtain from the natural environment, including natural resources that underpin basic human health and survival needs, support economic activities, and provide cultural fulfilment.
effluent	Any liquid, including particles of matter and other substances in suspension in the liquid.
emission	Air contaminant
environment or natural environment	All land, area beneath the land surface, atmosphere, climate, all water, surface water, ground water, sea, seabed, marine and coastal areas and natural resources, or any combination or part thereof.
environmental authorization	An environmental permit, a prescribed process license, a construction permit, or an operation permit.
environmental impact assessment	An assessment as provided in [Part IV, Environmental Impact Assessments, of the Environmental Protection Act].
equipment	Apparatus, device, mechanism, or structure.
embedded control	Physical or procedural controls that are planned as part of the Project design (i.e., not added solely based on a mitigation need identified by the impact significance assignment process). These are considered from the very start of

Term	Definition
	the impact assessment process as part of the Project, and are factored in to the pre-mitigation impact significance rating.
eutrophication	Over-enrichment of a waterbody with minerals and nutrients that can induce excessive growth of plants (including phytoplankton) or algae.
exploration	A term in the oil and gas industry referring to activities related to the search for oil and gas resources. Exploration operations can include aerial surveys, geophysical surveys, geological studies, core testing, and the drilling of test wells.
flare (or flaring)	In the oil and gas industry, a system of piping and burners used to dispose (by burning) of surplus gas or vapors produced with the oil and gas.
Floating Production Storage and Offloading (FPSO) vessel	A floating vessel that is used for offshore oil and gas operations and is designed to process hydrocarbons and store oil until the oil can be offloaded onto a tanker ship. The processing equipment (or topsides) is located on the FPSO's deck, while the oil storage is below the deck within the hull of the vessel.
flowline	The pipe through which oil travels from a production well to processing equipment or to storage.
freehold property	Property owned by the land user, not leased.
hawser	A taut line connecting the FPSO to tankers during offloading. The hawser helps the offloading tanker maintain a safe distance from the FPSO.
hazardous waste	A waste or combination of waste which, because of its quality, concentration, or physical, chemical, or infections characteristics, may pose a substantial hazard to human health and belong to any category contained in Schedule I [List of Hazardous Waste to be Controlled] unless they do not contain any of characteristics contained in Schedule II [List of Hazardous Characteristics] and includes waste that is: • Hazardous industrial waste • Acute hazardous waste chemical • Hazardous waste chemical • Severely toxic waste • Flammable waste • Corrosive waste • Reactive Waste • Radioactive waste • Clinical waste • Leachate toxic waste, or polychlorinated biphenyl waste, and includes a mixture of acute hazardous waste chemical, hazardous waste chemical, pathological waste, radioactive waste or severely toxic wastes, and any other waste or hazardous material
hazardous waste generation	The act or process of producing hazardous waste.
hazardous waste management	The systematic control of the collection, source, separation, accumulation, transportation, processing, treatment, recovery, and disposal of hazardous wastes.
holder	A person or corporate entity.
hydrostatic test	A way in which facilities such as pipelines, plumbing, gas cylinders, boilers, pressure vessels, and fuel tanks can be tested for strength and leaks. The test

Term	Definition
	involves filling the vessel or pipe system with a liquid, usually water, which may be dyed to aid in visual leak detection, and pressurizing the vessel or pipe system to the specified test point. Pressure tightness can be tested by shutting off the supply valve and observing whether there is a pressure loss.
hypoxia	Deficiency in dissolved oxygen concentrations.
ichthyoplankton	Fish eggs and larvae that drift with the ocean currents, usually near the surface, prior to developing directional swimming ability.
incinerator	Equipment used for the burning of waste
industrial	Of or pertaining to the manufacture, processing, handling, transport, importation, storage, or disposal of materials (including the extraction and conversion of mineral resources, raw materials, materials in the process of manufacture, manufactured materials, by-products, and any waste or water materials whether hazardous or not.
injection well	A well in which fluids, such as gas or water, are injected to increase pressure in the reservoir and drive the oil remaining in the reservoir to the vicinity of production wells.
inland waters	Any reservoir, pond, lake, river, stream, creek, canal, drain, spring, well, an part of the sea that are on the landward side of the territorial baselines, and any other body of natural or artificial surface or subsurface water.
institution	Health care establishments, medical facilities, hospitals, schools, and zoos.
Lagrangian	A type of model in which particles or parcels are moved under the influence of external forcing (winds, currents, buoyancy, turbulence, etc.) based on its individual location. The term is often used to differentiate such models from Eulerian models, where a field is established representing properties of interest (mass, concentration, etc.) in a discrete gridded space, and external forcing is applied to the entire property of that grid.
laydown area	An area that has been cleared for the storage of equipment and supplies. Laydown areas are usually covered with rock and/or gravel to ensure accessibility and safe maneuverability for transport and offloading vehicles.
manifolds	Gathering points or central connections made up of valves, hubs, piping, sensors, and control modules.
marine safety exclusion zone	A specific area of water where persons, vessels, and other activities are prohibited as the area has been designated for exclusive use by an activity; a form of safety control measure used to keep unauthorized persons and vessels away from a higher risk activity/event.
mobile sources	Any source of air pollution other than stationary sources, including but not limited to motor vehicles, off-road vehicles, marine vessels, and aircraft.
natural gas	A highly compressible, highly expansible mixture of hydrocarbons, which at atmospheric conditions of temperatures and pressure are in a gaseous phase.
natural resources	The living plants, animals and organisms, ecosystems, forests, waterways, soils, and other biological factors within the natural environment, and the geologic formations, mineral deposits, renewable and non-renewable assets, and the habitat of the living plants, animals, and organisms.
oil-equivalent barrels	A unit of energy based on the approximate energy released by burning one barrel of crude oil. Quantities of natural gas and natural gas liquids are often translated into oil-equivalent barrels. The energy content of 6,000 cubic feet of natural gas is roughly equivalent to the energy in one barrel of oil (i.e., one oil-equivalent barrel).

Term	Definition
parameter limit	The result of the analysis of any of the chemical factors which the [Guyana Environmental Protection Agency] may specify.
person responsible	In relation to any project, enterprise, construction, or development, includes any person who owns, operates, or exercises economic power or control over at whose order or on whose behalf the project, enterprise, construction, or development will be or, as the case may be, is being undertaken.
photo-oxidation	The process of chemical breakdown caused by exposure to sunlight.
pig	A specially designed device that is placed in the flowline at a launcher at one end and pushed by pressure until it reaches a receiving trap or catcher at the other end. Pigging is performed to aid in the maintenance, operations, cleaning, and/or inspection of flowlines and pipelines.
plugging and abandonment	When used in reference to a well after its productive life, the sealing of the well casing with materials (e.g., cement and/or mud) and removal of the wellhead.
pollution of the environment or environmental pollution	Pollution of the environment by the release into the natural environment of any contaminant.
produced water	Water that comes up a well with the oil and gas. Produced water is usually high in salinity. After leaving the well, the produced water is separated from the oil and gas. Can also be referred to as formation water, saltwater, or oilfield brine.
production well	A well that is used to retrieve petroleum or gas from an underground deposit.
reservoir	In the oil and gas industry, a porous and permeable sedimentary rock containing commercial quantities of oil and gas.
risers	The pipe and special fittings used on floating offshore drilling rigs to establish a seal between the top of the wellbore, which is on the ocean floor, and the drilling equipment, located above the surface of the water. A riser pipe serves as a guide for the drill stem from the drilling vessel to the wellhead and as a conductor of drilling fluid from the well to the vessel. The riser consists of several sections of pipe and includes special devices to compensate for any movement of the drilling rig caused by waves. Risers are also used to carry production fluids to the FPSO from the seabed and carry injection fluids (water and gas) from the FPSO to the seabed.
shorebase	A land-based facility that provides logistical and material support for offshore activities and facilities.
sludge	Any viscous, semisolid, or residue generated from a process
sound-making device	Any mechanism that is intended to, or which actually produces noise when operated or handled [Note: the remainder of the definition in the Act, which relates to musical sound, is omitted from this definition for the purposes of this EIA].
spread mooring system	A group of mooring lines distributed from the bow and stern of a vessel (FPSO) to anchors on the seafloor. The vessel is positioned in a fixed heading, which is determined by the sea and weather conditions. The symmetrical arrangement of anchors helps to keep the vessel on its fixed heading location. The spread mooring system does not allow the vessel to weathervane, which means to rotate in the horizontal plane due to wind, waves, or current.
stationary source	Any source of air pollution that is produced by a fixed or stationary location, including but limited to electrical installations.
structural casing	The outer layer of large-diameter, heavy-wall pipe installed in wells drilled from floating installations to isolate very shallow sediments from subsequent drilling, resist the bending moments imposed by the marine riser, and help support the wellhead installed on the conductor casing.

Term	Definition
transporter	Any person engaged in the transportation of hazardous waste.
umbilical	A cable and/or hose that provides the electrical, hydraulic, chemical, and communications connections needed to provide power and control between the FPSO and subsea equipment.
wellhead	A structure that is installed at the top of a natural oil or gas well. Its main function is to ensure a safe operation and manage the flow of oil or gas from the well into the gathering-system. It is a system composed of valves, spools, and assorted adapters that control the pressure of the production well. It acts as an interface between the surface facilities and the casing-strings in the wellbore.
wellhead tree	An assembly of valves, spools, pressure gauges, and chokes fitted to the wellhead of a completed well to control production.

ENVIRONMENTAL IMPACT STATEMENT

EXECUTIVE SUMMARY

In 2015, oil was discovered in the Liza field within the Stabroek Block, approximately 190 kilometers (120 miles) offshore from Georgetown in waters approximately 1,500 to 1,900 meters (932 to 1,180 feet) deep. Based on exploration and assessment activities to date, Esso Exploration and Production Guyana Limited (EEPGL) has estimated that the Stabroek Block contains more than 9 billion barrels (320 million cubic meters [m^3]) of oil-equivalent recoverable resource.

EEPGL (45 percent) and its co-venturers Hess Guyana Exploration Limited (30 percent) and CNOOC Petroleum Guyana Limited (25 percent) are parties to a Petroleum Agreement with the Government of Guyana.

EEPGL, on behalf of itself and its co-venturers, and in accordance with the Guyana Environmental Protection Act, is seeking an environmental authorization from the Guyana Environmental Protection Agency (EPA) for a fourth project development in the eastern half of the Stabroek Block (hereafter referred to as the Yellowtail Development Project, or "the Project"). The area that will be developed as part of the Project is located approximately 203 kilometers (approximately 126 miles) northeast of the coastline of Georgetown, Guyana. As part of its regulatory role, the EPA, considering recommendations from the Environmental Advisory Board and other government entities, is responsible for deciding whether and under what conditions to grant EEPGL's Application for Environmental Authorisation (Application), which was filed with the EPA on 1 April 2021. Based on an initial assessment of the Application, the EPA determined that an Environmental Impact Assessment (EIA) was required in support of the Application.

The purpose of the EIA is to provide the factual and technical basis required by the EPA to make an informed decision on EEPGL's Application for Environmental Authorisation. EEPGL conducted a robust public consultation program to both inform the public about the Project and to understand community and stakeholder concerns so this feedback could be incorporated and addressed in the EIA, as applicable.

The Project will consist of the drilling of approximately 45 to 67 development wells (including production, water injection, and gas re-injection wells); installation and operation of Subsea, Umbilicals, Risers, and Flowlines equipment; installation and operation of a Floating Production, Storage, and Offloading (FPSO) vessel in the eastern half of the Stabroek Block; and—ultimately—Project decommissioning. Onshore logistical support facilities and marine/aviation services will be used to support each stage of the Project. EEPGL will use proven and good international oilfield practices and has incorporated many embedded controls into the overall Project design to reduce environmental and socioeconomic impacts. It could take several years to drill the wells, currently scheduled from mid-2023 through 2028 (although drilling could begin as early as 2022).

The initial production is expected to begin by end of 2025–early 2026, with operations continuing for at least 20 years. The Project is expected to employ up to 540 persons during development well drilling, approximately 600 persons at the peak of the installation stage, and 100 to 140 persons during production operations.

The planned activities of the Project are predicted to have negligible residual impacts on most physical resources (air quality, marine geology and sediments, and marine water quality)—with potential moderate residual impacts on greenhouse gas (GHG) emissions, no impacts on coastal biological resources, negligible to minor residual impacts on most marine biological resources (with potential moderate residual impacts on special status marine fish), and negligible to minor residual impacts on socioeconomic resources—with largely positive impacts on socioeconomic conditions and employment. These predictions are based on the fact that the bulk of the Project activity will occur approximately 203 kilometers (approximately 126 miles) offshore, and the Project will capture and re-inject associated natural gas (that which is not used as fuel on the FPSO) back into the targeted Project reservoirs, treat all required effluent streams prior to discharge to the sea, have a very small physical footprint (e.g., infrastructure construction disturbs only about 0.7 square kilometer [0.3 square mile] of benthic habitat), and use Marine Mammal Observers and “soft starts” during seismic surveys to reduce the potential for auditory injury to marine mammals.

Unplanned events, such as a potential oil spill, are considered unlikely to occur because of the extensive preventative measures employed by EEPGL. Nevertheless, EEPGL has conducted oil spill modeling to evaluate the range of likely spill trajectories and rates of travel in the unlikely event of a spill. The location of the Project 203 kilometers (approximately 126 miles) offshore, prevailing northwest currents, the medium nature of the Yellowtail and Redtail fields’ crude oil, and the region’s warm waters would all help reduce the severity of a spill. A type of modeling known as stochastic modeling was performed for a number of spill scenarios. Stochastic modeling accounts for the variability in conditions such as winds and ocean currents by simulating hundreds of individual spills (theoretically occurring at different times and under different wind/current conditions) and generating a map that is a *composite* of all of the trajectories and provides a *probability footprint* showing the most likely path that a spill would follow. Stochastic modeling of an unmitigated subsea release of crude oil from a loss-of-well-control event indicates a less than 5 percent to 40 percent probability of oil reaching the Guyana coast, without taking into consideration the effectiveness of any oil spill response, and the low likelihood that such a spill would occur. Modeling of an unmitigated 2,500-barrel (400 m^3) release from an FPSO offloading spill indicates no impact to the Guyana coast.

Although the probability of an oil spill reaching the Guyana coast is low, a subsea release of crude oil from a loss-of-well-control event would impact marine water quality, marine sediments, and marine biological resources found near the well. Marine turtles and marine mammals would be particularly susceptible to impacts from an oil spill due to the need to surface to breathe and the resulting inhalation risks. Baleen whales feed near the surface where oil would be entrained, so an oil spill could foul their baleen plates and expose them to ingestion of oil as well as inhalation of volatized hydrocarbons. Should spilled oil reach the coast in Region 1, the risks of oiling nesting beaches could pose inter-generational risks to marine turtles. Other physical and

biological resources such as air quality, seabirds, marine fish, and marine benthos could also be impacted, although current speeds in the Project Development Area regularly exceed 1 meter (3.3 feet) per second and, as the deterministic modeling discussed in EIA Section 9.1.5, Oil Spill Modeling Results, demonstrates, spilled oil would travel rapidly to the north and/or west, depending on the season. Most of the biological resources listed are mobile and would be capable of at least some measure of avoidance of the higher hydrocarbon concentrations. This means that with the exception of immobile organisms in the immediate vicinity of the affected well, most physical and biological resources would likely experience impacts on the order of a few days at most.

Systemic ecological and food-web-related impacts could last longer depending on the extent of the acute impacts experienced from a spill event. Most species in the open ocean are at least somewhat mobile. This means that following initial detection of the oil, they would tend to avoid the affected area for the duration of the spill and return once the event is over, response activities are complete, and food resources recover. Given the likelihood that direct exposure to the effects of a spill would be short-term for most of these species, it is unlikely that an oil spill would cause widespread mortality and/or inter-generational impacts. The marine food web is based on planktonic organisms, many of which (with the exception of some fishes and a few macrobenthic species) would be expected to recover within a few weeks or months of the event. Even long-lived species with planktonic early life-stages would be expected to lose at most one year-class of recruits and recover through emigration from unaffected areas within a few years of the event.

A spill could potentially impact Guyanese fisherfolk if commercial fish and shrimp resources were impacted. The magnitude of this impact would depend on the volume and duration of the release as well as the time of year at which the release were to occur (e.g., whether a spill would coincide with the time of year when these species are more abundant in the Project Development Area). Based on the results of the studies, fish diversity and abundance generally increase in the nearshore zone in the rainy season, marine turtle presence shows little variation over the seasons in terms of their abundance offshore, and marine mammals are more abundant in autumn and winter. Marine turtles are relatively abundant offshore Region 1 during the nesting season, but less common at other times of year. Regardless of seasonal trends in abundance or spatial distribution among the major taxonomic groups, effective implementation of the Oil Spill Response Plan (OSRP) would reduce this risk by reducing the ocean surface area impacted by a spill and thereby reducing potential exposure of these species to oil.

Oil spill modeling indicates that transboundary impacts could potentially occur for the largest spill scenarios considered. These include a 2,500-barrel (400 m^3) release from an FPSO offloading spill and two loss-of-well-control scenarios: the Most Credible Worst Case-Discharge (WCD), which would be predicted to discharge 88,728 barrels of oil per day (BPD) (14,196.5 m^3), and the WCD, which would be predicted to discharge 177,157 BPD (28,345.1 m^3), assuming no mitigation measures were implemented. The unmitigated modeling results for these scenarios indicate there is the potential for oil to reach portions of a number of countries in the Caribbean. Potential impacts on resources and receptors in these other countries would be similar to those for Guyana. Further, there are some additional resources

that could potentially be affected (e.g., corals), which recent marine surveys have documented are sparsely distributed across the middle and outer continental shelf and continental slope.

Additional unplanned events could include collisions between Project vessels and third-party vessels; Project vessel strikes of marine mammals, marine turtles, riverine mammals, or rafting seabirds; collisions between Project vehicles and third-party vehicles; Project helicopter strikes with seabirds; and discharge of untreated wastewater from the Project FPSO. All of these events are also considered unlikely to occur because of the preventative measures employed by EEPGL. The extent of the impacts from these types of events would depend on the exact nature of the event. However, in addition to reducing the likelihood of occurrence, the embedded controls that will be put in place by EEPGL (e.g., training of vessel operators to recognize and avoid marine mammals, riverine mammals, and marine turtles; adherence to international and local marine navigation procedures; adherence to a Road Safety Management Procedure) would also serve to reduce the likely extent of impact, were such an event to occur.

Although a large marine oil spill is considered unlikely and the probability of reaching the Guyana coast is low, given the sensitivity of many of the resources that could be potentially impacted by a spill (e.g., Shell Beach Protected Area, marine mammals, special status marine turtles and seabirds, coastal Guyanese and Amerindian communities reliant on ecosystem services for sustenance and their livelihood), preparation for spill response is warranted. Therefore, EEPGL will implement from time to time regular oil spill response drills, simulations, and exercises. EEPGL will involve appropriate Guyanese authorities and stakeholders in these activities and document the availability of appropriate response equipment on board the FPSO as well as offsite equipment required to be mobilized for a timely response.

With respect to potential transboundary impacts from an oil spill, implementation of EEPGL's OSRP would help to significantly reduce potential transboundary impacts just as it would reduce impacts within the Guyana Exclusive Economic Zone, as demonstrated by oil spill modeling that considers OSRP implementation (i.e., mitigated scenarios). In particular, EEPGL has put in place an interim solution that will facilitate installation of a capping stack on the well location. At the time the EIA was submitted, the response time associated with deployment of the capping stack system (specifically the Boots & Coots Global Rapid Intervention Package [GRIP] system) was based on preliminary and conservative logistics assumptions. After establishing the subscription to the Boots & Coots GRIP system, and in conjunction with an ongoing capping stack study, the response-time model has been refined to reflect current logistics strategies and it is now estimated that the capping stack deployment is possible within 5 days. The 5-day period is an installation-ready time estimate for deployment of the capping stack, which includes logistics mobilization (aircraft, deployment vessel), stack configuration and testing, load-out, and transit times.

Therefore, modeling for a mitigated loss-of-well-control scenario is based upon a 5.5-day response time for deployment and installation of the capping stack at the well for the WCD scenarios and that timing is reflected in the mitigated scenarios modeling. Mitigated scenario modeling demonstrates that this, in combination with other response measures (e.g., dispersant application), would significantly reduce the extent of transboundary impacts. Additionally,

EEPGL has committed to work with the Government of Guyana for the coordination of applicable activities with representatives of the respective countries that could be potentially impacted by a large oil spill.

It is recommended that all of EEPGL's planned embedded controls, as well as the mitigation measures described herein, and appropriate Environmental and Socioeconomic Management Plan components, including an OSRP, be adopted. With the adoption of such controls, mitigation measures, and management plans, and requirements for emergency response preparedness, the Project is expected to pose only minor to moderate risks to the environmental and socioeconomic resources of Guyana, while potentially offering significant economic benefits to the residents of Guyana.

1. INTRODUCTION

This Environmental Impact Statement was prepared for the Yellowtail Development Project (Project) in accordance with the Guyana Environmental Protection Act (as amended in 2005), the Environmental Protection (Authorisation) Regulations (2000), the Environmental Impact Assessment Guidelines—Volume 1, Version 5 (EPA 2004), the Environmental Impact Assessment Guidelines—Volume 2, Version 4 (EPA/EAB 2000), good international oilfield practice, Esso Exploration and Production Guyana Limited's (EEPGL's) standards, and the Project's Final Terms and Scope (10 September 2021) for the Project Environmental Impact Assessment (EIA).

The EIA was prepared by a team of consultants including Environmental Resources Management (ERM), an international environmental and social consulting firm with a local registration in Guyana and extensive experience in the preparation of EIAs for offshore oil and gas development projects; SLR Consulting (SLR);and the Guyanese consultancies Caribbean Engineering and Management Consultants (CEMCO), Leon Moore Nature Experience (LMNE), and the University of Guyana Centre for the Study of Biological Diversity (CSBD). ERM, CEMCO, LMNE, and CSBD are collectively referred to herein as "the Consultants." Appendix B provides the curricula vitae of the key members of the EIA team.

1.1. PROJECT SPONSOR

EEPGL is the designated Operator of the Stabroek Block and is seeking authorization for the Project on behalf of itself and Hess Guyana Exploration Limited and CNOOC Petroleum Guyana Limited (EEPGL's "co-venturers"). EEPGL will be the operator of the Project and is used in this EIA to represent the joint venture. EEPGL is an indirectly owned affiliate of Exxon Mobil Corporation.

1.2. PROJECT CONTEXT

EEPGL (with the co-venturers) holds an offshore Petroleum Prospecting Licence for the Stabroek Block from the Government of Guyana. In 2015, oil was discovered in the Liza field within the eastern half of the Stabroek Block.

Following that discovery and based on exploration and assessment activities to date, EEPGL has identified the presence of multiple reservoirs of crude oil with an estimated recoverable resource in excess of 9 billion barrels of oil-equivalent resource in the eastern half of the Stabroek Block. EEPGL and its co-venturers are parties to a Petroleum Agreement with the Government of Guyana. The Project described herein represents EEGPL's fourth project development in the eastern half of the Stabroek Block, in the Yellowtail and Redtail fields. The Project is located approximately 203 kilometers (approximately 126 miles) northeast of the coastline of Georgetown in waters approximately 1,700 to 1,900 meters (5,577 to 6,234 feet) deep (Figure EIS-1).

1.3. PURPOSE OF THE PROJECT

The purpose of the Project is to achieve safe and efficient production of hydrocarbons from the Yellowtail and Redtail fields.

1.4. REGULATORY FRAMEWORK AND PURPOSE OF THIS EIA

To develop the Project, EEPGL has applied for a Project environmental authorization from the Guyana Environmental Protection Agency (EPA) in accordance with the Guyana Environmental Protection Act (as amended in 2005). To that end, EEPGL filed its application with the EPA on 1 April 2021 (Application). As part of its regulatory role, the EPA, taking into consideration recommendations from the Environmental Advisory Board and other government entities, is responsible for deciding whether and under what conditions to approve EEPGL's Application. Based on an initial assessment of the Project, the EPA determined that an EIA is required. The purpose of the EIA is to provide the factual and technical basis required by EPA to make an informed decision on EEPGL's Application.

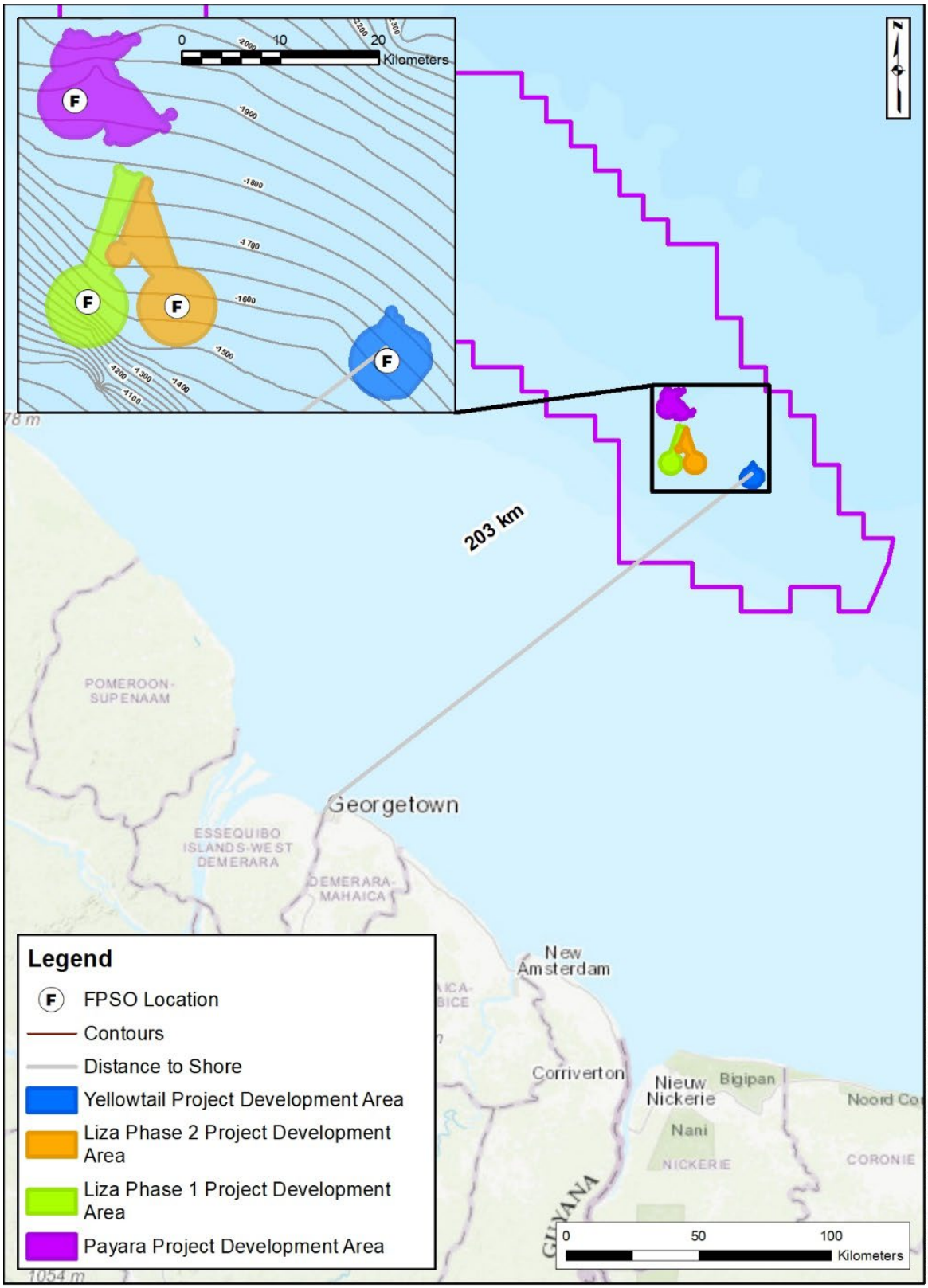


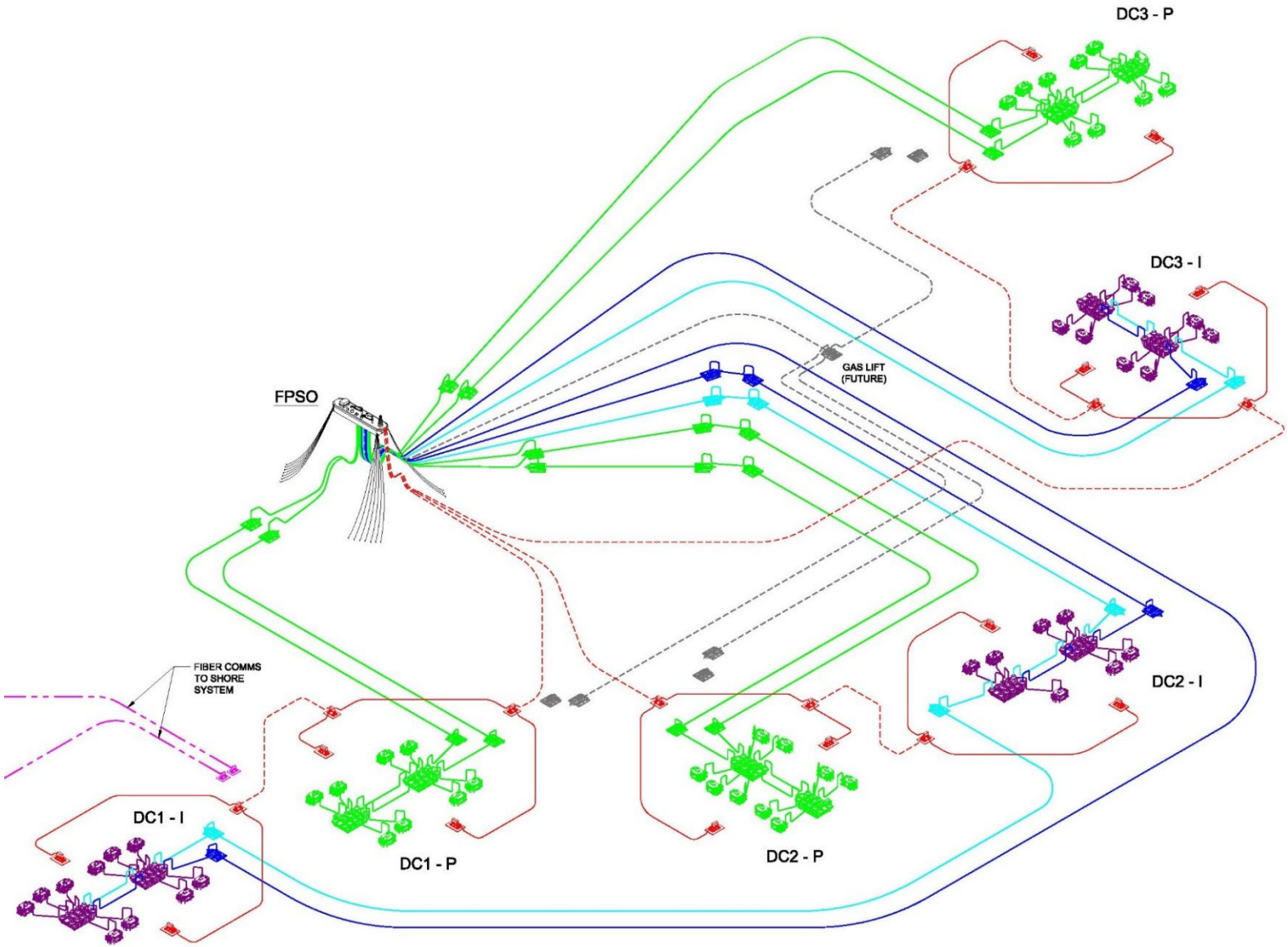
Figure EIS-1: Location of the Yellowtail Project Development Area within Stabroek Block

2. PROJECT DESCRIPTION

The Project will develop the offshore resource by drilling approximately 45 to 67 development wells (including production, water injection, and gas re-injection wells) and using a Floating Production, Storage, and Offloading (FPSO) vessel to process, store, and offload the recovered oil. The FPSO will be connected to the wells via associated equipment, collectively referred to as Subsea, Umbilicals, Risers, and Flowlines (SURF) (Figure EIS-2), to transmit produced and associated fluids (i.e., oil, gas, and produced water) from production wells to the FPSO, as well as treated gas and water from the FPSO to the injection wells. The combined extent of the area affected by both surface and subsea components and activities is referred to as the Project Development Area (PDA). The exact locations of the Yellowtail development wells have not yet been finalized; however, the wells will be drilled from six drill centers. During drilling and installation of the FPSO/SURF facilities, work may be performed in a subsea area within the PDA that could potentially cover an estimated 3,534 hectares (8,733 acres). This area is referred to as the Subsea PDA. During the production operations stage, work performed on the surface of the ocean could potentially cover an estimated 4,576 hectares (11,308 acres). This area is referred to as the Surface PDA. The Project will also involve use of onshore shorebases and other support facilities and marine/aviation services to support development drilling, SURF and FPSO installation, production operations, and, ultimately, decommissioning.

Natural gas will be produced in association with the produced oil. EEPGL will use some of the recovered gas as fuel on the FPSO and proposes to re-inject the remaining gas back into the reservoir, which will assist in optimizing management of the reservoir. Alternative uses of gas for future phases are being studied and any such uses would be addressed in a separate environmental authorization.

The Project life cycle will consist of three main stages: (1) Drilling and Installation, (2) Production Operations, and (3) Decommissioning. Each of these stages is described briefly below.



Green = oil flowlines; light blue = gas injection; dark blue = water injection; red = umbilicals; gray = gas lift

Figure EIS-2: Preliminary Yellowtail Field Layout

2.1. DRILLING AND SURF/FPSO INSTALLATION

The Project will use several drill ships similar to the vessel shown on Figure EIS-3 to drill the development wells. The number of drill ships required will be determined during the design development process based primarily on the number of wells required for initial oil production. For the purposes of environmental assessment, three full-time drill ships working concurrently on Project development wells was the basis of analysis. Additional drill ships may be used to accelerate the drilling schedule, as allowed by simultaneous operations. The wellheads will be clustered around six drill centers rather than being distributed over the seabed above the producing reservoirs. For safety reasons, a 500-meter (approximately 1,640-foot) marine safety exclusion zone around the drill ships and major installation vessels will be established to avoid interactions with unauthorized vessels.

Figure EIS-3: Typical Drill Ship

For each well, the initial section (i.e., structural casing section) will feature a pipe inserted into the borehole and cemented in place. This section will be drilled using water-based drilling fluids, and drill cuttings from this section will be discharged to the seafloor near the well. Subsequent (lower) sections of the wells will be drilled using low-toxicity non-aqueous drilling fluids (NADF) with low to negligible aromatic content. The used cuttings from the lower sections will be directed to the drill ship, where the drilling fluids will be recovered for reuse to the extent practicable and the cuttings will be treated to limit the percentage of fluid retained on the

cuttings. After treatment, the cuttings will be discharged to the sea. As each well is drilled, a wellhead and tree will be installed and the well will be connected to a manifold, which will be connected to a production or injection flowline. The flowlines will be laid on the seafloor, and risers will connect the seafloor infrastructure to the FPSO. The flowlines and risers will be hydrostatically tested with treated seawater to ensure no leakage. After the testing, the hydrostatic water used to test the water and gas injection flowlines will be discharged near the seafloor, and the fluid used to test the production flowlines will be recovered and treated prior to discharging overboard.

The FPSO (Figure EIS-4) will be new-built with double-hull protection, with the capacity to store 2 million barrels (320,000 m^3) of stabilized crude oil. The FPSO will be secured to the seafloor by an up to 22-point spread mooring anchor system. The FPSO and the mooring system will be designed to remain in place for at least 20 years and accommodate extreme (100-year return period) environmental conditions (associated wind, waves, and current). The FPSO will also provide living quarters and associated utilities for up to 160 personnel. For safety reasons, the FPSO will have a 2-nautical mile (3.7-kilometer) exclusion zone during offloading to avoid interactions with unauthorized vessels.

Figure EIS-4: Typical FPSO

2.2. PRODUCTION OPERATIONS

The FPSO will be designed to separate the recovered reservoir fluids into its oil, water, and gas phases (Table EIS-1). The oil will be treated to remove impurities (e.g., sulfate and other salts) and then sent to storage tanks in the hull. The water from the reservoir (referred to as produced water) will be treated to remove hydrocarbons and will then be discharged to the sea. The

FPSO will dehydrate, compress, and re-inject the associated natural gas into the targeted Project reservoirs, although some of the gas will be used as fuel on the FPSO, and some gas may be occasionally flared on a temporary, non-routine basis as a measure to prevent process safety incidents. The FPSO will also have the capacity to treat (by filtration, deaeration, and sulfate removal) seawater for injection into the reservoir to maintain reservoir pressure (and offset the withdrawal of reservoir fluids) to enhance oil production.

Table EIS-1: FPSO Key Design Rates

Service	Annual Average [b]
Oil Production, BPD (m^3/d)	250,000 (40,000)
Water Production, BPD (m^3/d)	225,000 (36,000)
Total Liquids Production, BPD (m^3/d)	300,000 (48,000)
Gas Production, MMscfd ($MMsm^3$/d)	450 (12.7)
Gas Injection, MMscfd ($MMsm^3$/d) [a]	415 (11.8)
Water Injection, BPD (m^3/d)	300,000 (48,000)

BPD = barrels per day; m^3/d = cubic meters per day; MMscfd = million standard cubic feet per day; $MMsm^3$/d = million standard cubic meters per day
[a] Assumes 35 MMscfd of associated gas will be used as fuel gas for the FPSO.
[b] Design rates presented are annual averages and peak rates may be higher during the lifetime of the Project, depending on multiple factors (e.g., reservoir pressure, number of wells, equipment reliability, etc.).

The FPSO will offload produced crude oil to conventional oil tankers on a regular basis. The tanker, under the guidance of a Mooring Master, will maneuver to within approximately 120 meters (390 feet) of the FPSO and hold position with the aid of up to three tugboats (Figure EIS-5). Crude oil will be pumped from the FPSO storage tanks to the offloading tanker using a floating hose at a rate of approximately 1 million barrels (160,000m^3) of oil in approximately 24 hours.

Figure EIS-5: General Offloading Configuration

2.3. DECOMMISSIONING

In advance of the completion of the Yellowtail production operations stage, EEPGL will prepare a decommissioning plan for the facility. EEPGL will perform comparative assessments of facilities components where there may be multiple decommissioning options. Wells will be permanently plugged and abandoned by restoring suitable cap rock to prevent escape of hydrocarbons to the environment. Plugging and abandonment barriers will be installed in the wellbore, of adequate length to contain reservoir fluids, and deep enough to resist being bypassed by fracturing. It is expected that the risers, flowlines, umbilicals, subsea equipment, FPSO mooring lines, and anchor piles will be disconnected and abandoned in place on the seafloor, unless an alternative strategy is selected based on the results of the comparative assessments. The FPSO will be disconnected from its mooring system, removed from the production location, and towed to a new location for re-use or decommissioning.

2.4. ONSHORE, MARINE, AND AVIATION SUPPORT

Shorebases, laydown areas, pipe yards, fabrication/maintenance facilities, warehouses, fuel supply, heliport, and waste management facilities are planned to support development drilling, FPSO/SURF installation, production operations, and ultimately, decommissioning. EEPGL plans to use existing Guyana shorebases to support the Project; new onshore facilities in Guyana may also be used by the Project (these would be developed by third parties as separate projects). All onshore support facilities will be owned/operated by others and will not be dedicated to the Project.

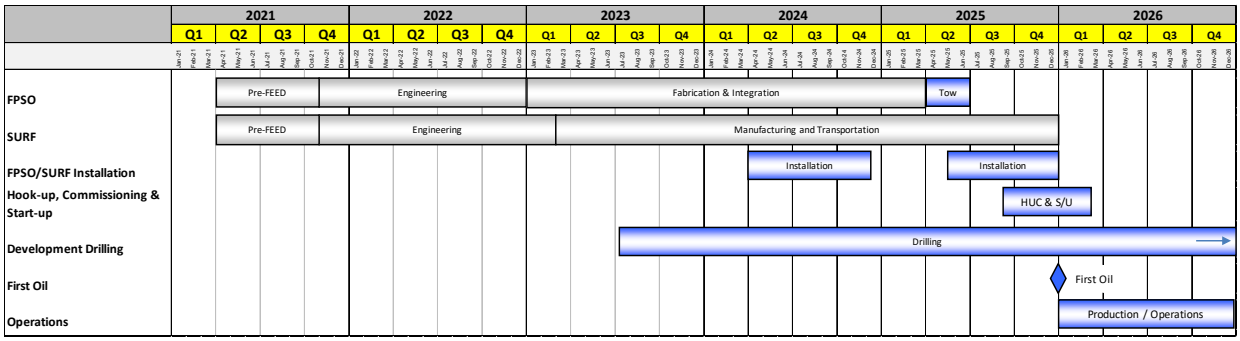
Marine support will include various supply vessels with an average of approximately 12 to 15 round-trips per week to the Stabroek Block (combined for Liza Phase 1, Liza Phase 2, Payara, and Yellowtail) during development drilling and FPSO/SURF installation and approximately three to five round-trips per week (combined for Liza Phase 1, Liza Phase 2, Payara, and Yellowtail) during production operations. The vessels will be loaded and offloaded at shorebase facilities in Guyana and/or Trinidad. Aviation support is expected to average at peak about 20 to 25 round-trip flights per week during drilling and installation (combined for Liza Phase 1, Liza Phase 2, Payara, and Yellowtail) and an estimated five to seven round-trip flights per week during production operations and continued development-drilling activities (combined for Liza Phase 1, Liza Phase 2, Payara, and Yellowtail).

2.5. PROJECT WORKFORCE

EEPGL estimates it will require a workforce of approximately 540 persons at the peak of the development well drilling, approximately 600 persons at the peak of the installation stage, approximately 150 shorebase and marine logistical support onshore staff (some of whom will be Project-dedicated while others will be shared resources) at the peak of installation and drilling activities, approximately 100 to 140 persons at peak of production operations, and approximately 60 persons at the peak of decommissioning.

2.6. PROJECT SCHEDULE

It could take several years to drill the approximately 45 to 67 wells, with drilling currently scheduled from mid-2023 through 2032.[1] Installation of the SURF and FPSO is planned to be initiated in 2025 to be ready for initial production by early 2026, with operations continuing for at least 20 years (Figure EIS-6).



HUC = hook-up and commissioning; SU = Start Up
This reflects the current preliminary Project schedule and remains subject to adjustment. Some activities (e.g., development drilling, HUC. and SU) may begin earlier than indicated pending receipt of environmental authorization or continue longer due to unforeseen delays.

Figure EIS-6: Preliminary Project Schedule

2.7. PUBLIC CONSULTATION

EEPGL and the Consultants have conducted a robust public consultation program to both inform the public about the Project and understand stakeholder concerns so they could be incorporated into the EIA, as appropriate. The different stages of the Project each require stakeholder engagement that is tailored in terms of its objectives and intensity, as well as the forms of engagement used. The various engagements completed or planned specific to the EIA stage are summarized below.

- EEPGL has held a number of engagements and workshops on specific topics with the government and agencies related to the offshore oil and gas exploration and development in general and the Yellowtail Development Project specifically.
- During scoping and the EIA development, EEPGL and/or the Consultants:
  - Engaged with and/or gathered relevant data from more than 50 Guyana government agencies, commissions, professional or business associations, non-governmental organizations, and elected officials and regional administrators;

[1] The Yellowtail drilling campaign could commence as early as the second quarter of 2022 for the purposes of accelerated subsurface data collection and optimal use of the Stabroek drill ship time. The potential scope for 2022 drilling could include top-hole sections of up to five wells, but likely no completions in the reservoir interval(s). In this case, wells would be temporarily plugged and re-entered for completion operations during the primary drilling campaign for the Yellowtail project. Drilling could extend as late as 2032 depending on the total number of wells drilled.

- Held scoping meetings with more than 200 participants, including members of coastal communities; and
- Engaged with Regional Democratic Councils and Neighbourhood Democratic Councils in Regions 1 through 6.

A Notice to the Public concerning the submission of the Application for the Project was published in the Stabroek News on 9 May 2021, and was posted on the EPA's website, initiating the 28-day public comment period. During this period, seven public consultation meetings with the public were held.

These meetings are documented in the Stakeholder Engagement Plan and information received from these engagements was incorporated into the existing conditions and impact assessment components of the EIA, as appropriate.

2.8. ALTERNATIVES

The EIA considered a range of potential Project alternatives, as summarized below:

- Location Alternatives. The location of the offshore Project infrastructure, particularly the development wells and SURF hardware, is primarily driven by the location of the resource to be recovered. However, within the proximity of the resource, there is some flexibility in selecting the location of the FPSO and associated mooring system within the PDA. The locations/orientations of FPSO, SURF equipment, and drill centers were selected to reduce to the extent practicable the potential impacts on the environment and to optimize the recovery of resources. A key consideration in FPSO location is to minimize interference and facilitate efficient four-dimensional seismic operations in the Stabroek Block. Another consideration for the FPSO location is to avoid positioning FPSO anchor piles in areas that could create geotechnical challenges. Routing of flowlines/pipelines/risers between the manifolds and FPSO primarily seeks to minimize overall length while also avoiding clashing (e.g., between risers, umbilicals, and mooring lines). Minimizing length not only reduces Project cost, but also Project footprint (and impact). The FPSO and subsea equipment locations were chosen so that initial projects can be operated, including the marine operations associated with oil offloading, while subsequent projects are in the drilling or offshore installation phases. With respect to onshore components of the Project, existing shorebases in Georgetown will be used along with new shorebases as needed and available to provide sufficient capacity to meet Project needs. If additional shorebases are developed in the future by third parties through separate permitting processes, EEPGL will consider the potential benefits (environmental, technical, and economic) of using these shorebases in addition to or in lieu of the shorebases that currently exist.
- Development Concept Alternatives
  - Drilling Facility Type: The primary alternatives considered for development well drilling facilities included a drill ship and a semi-submersible drilling rig. Drill ships allow for more efficient development operations as compared to semi-submersibles, given their increased variable deck load—which is critical due to multi-well drilling and completion

equipment requirements. Drill ships also allow for faster transit speeds between drill centers, resulting in significant time-savings due to frequency of well movements during batch operations.

- Production Facility Type: Several different types of production facility alternatives were evaluated during the early stages of the design process. Given the water depth and distance to shore of the Yellowtail and Redtail fields, the development alternatives for the Project are primarily limited to floating production systems (e.g., FPSO, semi-submersible, tension leg platforms). Regardless of the structure, the chosen facility for the Project would need to process the same volumes of oil, gas, and water. As such, topsides facilities are similar between an FPSO and a semi-submersible. The most substantial distinction between an FPSO and a semi-submersible platform is the need for oil storage. An FPSO has storage integrated into its facilities. A semi-submersible would require an additional floating, storage, and offloading (FSO) facility to allow for the oil storage. The FSO adds cost above the FPSO design and a semi-submersible with an FSO would also require additional moorings as compared to an FPSO. The use of an FSO would thus significantly increase the Project offshore infrastructure, which could increase potential Project impacts on air quality (e.g., increased air emissions), marine water quality (e.g., additional effluent discharges), marine benthos (e.g., increased disturbance of the seafloor for the FSO mooring system), and marine use and transportation (e.g., additional marine safety exclusion zones for additional marine vessels). For these reasons, an FPSO was selected as the preferred production facility alternative for the Project.
- Crude Oil Commercialization: The principal alternatives for an offshore development are: (1) transmission to shore via subsea pipeline infrastructure to an onshore refining facility; and (2) offloading to export tankers for transport to onshore refining facilities located further from the resource than can be feasibly connected via pipeline infrastructure. As there are no existing petroleum refineries in Guyana or existing regional offshore pipeline infrastructure in close proximity, the only feasible alternative is offloading to export tankers for sale to existing refining facilities around the world.
- Associated Gas Management: Three primary alternatives were considered for addressing associated gas produced during Project operations: gas re-injection, continuous flaring, and gas export. Gas re-injection was determined to be feasible for the Project, and it also provides benefits in terms of reservoir management by helping to maintain pressure in the reservoir (thereby increasing the amount of crude oil that can be recovered over time) and reduced air emissions (as compared to continuous flaring). Under this alternative, associated gas not used as fuel gas on the FPSO will be re-injected under normal operations. Continuous flaring of the associated gas on a routine basis is not preferred, primarily due to the associated air emissions. Gas export alternatives for future development continue to be evaluated, with due consideration of the challenges related to commercialization of associated gas. There is currently a separate project being proposed to transport a portion of the gas from the Liza FPSOs to shore, where it would be used to generate power in a gas-fired power plant. As this

project would satisfy the currently identified gas demand in Guyana, there is not enough additional demand in Guyana to consume the quantities of associated gas that will be produced from the Yellowtail Development Project. Any proposal for implementation of gas export would be addressed under a separate environmental authorization process and is therefore outside the scope of this EIA.

- Technology Alternatives. EEPGL is using the most appropriate industry-proven technologies in developing the Project, in terms of well drilling, drilling fluids, equipment selection, development concepts, and environmental management. EEPGL's parent company Exxon Mobil Corporation, its affiliates, and their contractors have extensive experience in delivering offshore deepwater development projects around the world, particularly with FPSO and SURF components, and are applying that knowledge, experience, and technology in the development of this Project. EEPGL evaluated the best available technology decisions, which consider economic and technical feasibility, as well as the facilities and controls described in the EIA, for the following technology aspects: drill cuttings, gas processing, injection compressors, power generation, produced water, and sulfate removal.
- No Action Alternative. If this alternative is selected, the existing conditions described in EIA Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8 Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources, would remain unaffected by the Project and the potential positive and negative impacts assessed in these chapters would not be realized. Therefore, evaluating the no action alternative means evaluating the tradeoff between positive and negative impacts.

Overall, the proposed Project reflects optimized locational siting, appropriate development concept, use of industry-proven technology, and selection of the environmentally preferred action alternative.

3. PROJECT IMPACTS

This section summarizes the predicted environmental and socioeconomic impacts of the Project resulting from planned activities and potential risks resulting from unplanned events, as well the Project's contributions to cumulative impacts on resources and receptors. The resources/receptors considered in this analysis are listed in Table EIS-2. The potential impacts of the Project were evaluated against the conditions of the existing environment, as described in Chapters 6, 7, and 8 of the EIA.

Table EIS-2: Resources and Receptors Considered in this EIA

Physical Resources	Biological Resources	Socioeconomic Resources
Air Quality, Climate, and Climate Change	Protected Areas and Special Status Species	Socioeconomic Conditions
Sound	Coastal Habitats	Employment and Livelihoods
Marine Geology and Sediments	Coastal Wildlife	Community Health and Wellbeing
Marine Water Quality	Seabirds	Marine Use and Transportation
	Marine Mammals	Social Infrastructure and Services
	Riverine Mammals	Cultural Heritage
	Marine Turtles	Waste Management Infrastructure Capacity
	Marine Fish	Land Use
	Marine Benthos	Ecosystem Services
	Ecological Balance and Ecosystems	Indigenous Peoples

3.1. PLANNED ACTIVITIES

The Project is an offshore oil development and all drilling, installation, production operations, and decommissioning activities will occur over 203 kilometers (approximately 126 miles) off the coast of Guyana. The planned Project activities will not disturb any natural onshore habitats. The Project will generate benefits for the citizens of Guyana through revenue sharing with the Government of Guyana, a positive but minor increase in employment, and select Project purchasing from Guyanese businesses. The resources with the potential to incur meaningful impacts (impacts with a significance rating of Minor or higher) from planned Project activities are the physical resources water quality and climate, some marine-oriented biological resources, and some socioeconomic resources. These resources and their residual significance ratings (after mitigation measures are considered) are discussed briefly below. Resources that are not expected to incur impacts with significance ratings higher than Negligible from planned Project activities are not discussed in this section.

3.1.1. Air Quality, Climate, and Climate Change

Emissions generated by the Project generally emanate from two source categories: (1) specific point sources such as the power-generating units and diesel engines on drill ships and on the FPSO, non-routine flaring used to combust associated gas when not consumed as fuel gas on the FPSO or injected back into the reservoir, and low-level routine flaring (pilot/purge gas) for safe operation of the flare as well as small streams that cannot practically be recovered by vapor recovery; and (2) general area sources such as marine support vessels, installation vessels, and helicopters. Such emissions contribute to increases in the ambient air concentrations of certain pollutants.

The CALPUFF model was used to assess the dispersion of air pollutants and the potential impact for onshore human receptors. For all modeled constituents, the maximum onshore

concentrations predicted to result from Project activities are negligible relative to ambient air quality guidelines (the maximum predicted onshore concentrations are all less than 6.3 percent of the applicable guidelines), indicating a **Negligible** residual impact on onshore air quality from the Project.

The Project will also emit GHGs throughout its predicted life cycle (at least 20 years), with average annual emissions during production operations estimated to be between approximately 1.11 and 1.40 million tonnes of carbon dioxide-equivalents (CO_2e) per year. There are no applicable regulatory criteria against which these GHG emissions can be compared, but these emissions will be disclosed in accordance with good international oilfield practice to aid in managing GHG emissions at a national and international level. EEPGL proposes to re-inject recovered natural gas that is not used as fuel on the FPSO back into the targeted Project reservoirs for reservoir pressure management, which contributes to a significant reduction in potential GHG emissions versus that which would result from continuous gas flaring. Guyana's estimate of annual GHG emissions in 2004 was approximately 4.7 million tonnes of CO_2e, with total annual removals of approximately 61.5 million tonnes of CO_2e (resulting in net annual removals of approximately 56.9 million tonnes of CO_2e). Accordingly, although the overall emissions at a country level would be increased measurably by Project GHG emissions, net removals would decrease between only approximately 2 and 3 percent.

Further, the Project has applied technologies aligned with good international oilfield practice to reduce GHG emissions. The estimated 1.11 to 1.40 million tonnes of CO_2e per year annual emissions rate represents an 80.2 to 83.6 percent reduction from projected GHG emissions without such technologies (i.e., routine flaring of natural gas not used as fuel for the FPSO, no embedded controls, and no mitigation measures). Balancing these factors with the fact that climate change is an issue of global importance, a residual significance rating of **Moderate** is applied for the production operations stage of the Project.

3.1.2. Marine Water Quality

The Project will impact marine water quality in a localized manner via planned discharges during well drilling, hydrostatic testing of the flowlines and risers following installation, and production operations stages. Planned discharges of drill cuttings and fluids may have a localized impact on marine water quality as a result of increased total suspended solids (TSS) concentrations in the water column. Cuttings and fluids released at the seafloor during jetting and drilling of the initial sections of the well will increase TSS concentrations around the well near the seafloor. Cuttings discharged overboard from the drill ships will increase TSS concentrations in the photic zone (the upper level of the water column through which sunlight can penetrate). Modeling predicts that TSS concentrations above a threshold of 35 milligrams per liter (mg/L) will occur during drilling of the initial well sections only, and these instances are confined to within a relatively small area around the well locations, near the seafloor. The area impacted will be localized and impacts will occur over a short time period; however, a small fraction of the overall benthic community (sponges living on the hard seafloor features in the PDA) would have an

elevated sensitivity to elevated TSS, so the residual impacts on marine water quality from TSS increases resulting from drill cuttings discharge are considered **Minor.**

During installation, the subsea flowlines and risers must be hydrostatically tested to confirm there are no leaks. Treated seawater is used for this purpose to prevent biofouling. A hydrate-inhibiting substance, such as methanol or ethylene glycol, will also be used to prevent formation of hydrates during commissioning of the production and gas injection lines. After testing is completed, the hydrostatic test water from the water injection and gas injection lines, and the hydrate inhibitor from the gas injection lines will be released at the seafloor. The hydrostatic test water and hydrate inhibitor from the production lines will be returned to the FPSO, treated, and discharged from the overboard water line. These discharges would be a one-time, short-term impact, and the treated seawater and hydrate inhibitor would be quickly diluted within the water column, resulting in a **Negligible** residual impact.

During production operations, the FPSO will discharge several primary effluent streams to the ocean (Table EIS-3). The FPSO systems associated with these discharges will be designed to ensure applicable discharge criteria are met, which may require treatment in some cases.

Modeling indicates that concentrations of chemical constituents would be reduced to insignificant levels and temperature increases from cooling water and produced water discharges will be less than 3°C (5.4°F) within approximately 100 meters (approximately 328 feet) of the discharge point, resulting in a **Negligible** residual impact.

Table EIS-3: Summary of Production Operations Discharges

Discharges	Source	Potential Contaminants	Estimated Discharge Rate	Comments
Cooling Water	Process water to dissipate heat from FPSO systems, no hydrocarbon contact	Temperature, residual chlorine	≤ 1,900,000 BPD (≤ 304,000 m^3 per day)	Discharge will meet good international oilfield practice limiting increases in ambient water temperature. Discharge meets applicable International Maritime Organization (IMO) residual chlorine standards without treatment (World Bank 2015; IMO 2004).
Produced Water	Water separated from reservoir fluids	Oil and grease, temperature, residual production and water treatment chemicals	≤ 225,000 BPD (≤ 3,600 m^3 per day)	Will be treated to meet World Bank Environmental Health and Safety Guidelines on oil and grease content. Discharge will meet good international oilfield practice limiting increases in ambient water temperature (World Bank 2015; IMO 2004).
Sulfate Removal, Ultrafiltration and Wash Water Processing Brines	Removal of sulfates from seawater prior to injection; wash water processing	Biocide, chlorine, oxygen scavenger, scale inhibitor	≤ 315,000 BPD (≤ 50,400 m^3 per day)	Discharge meets applicable standards without treatment.

Discharges	Source	Potential Contaminants	Estimated Discharge Rate	Comments
FPSO Bilge Water	FPSO bilge water	Oil and grease	1,800 BPD (288 m^3 per day)	Will be treated to meet the International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978, requirement on oil and grease content.
Domestic and Sanitary Wastewater	Personnel black water and food wastes (treated); grey water (untreated)	Nutrients, chlorine, bacteria	<375 BPD (<60 m^3 per day)	Will be treated in accordance with good international oilfield practice prior to discharge, as required (World Bank 2015; IMO 2004).
Offloading Tanker Ballast Water	Offloading tanker will discharge ballast water as it loads oil from the FPSO	None anticipated	≤ 629,000 bbl (≤ 100,000 m^3) total (at each tanker loading)	Discharge will be conducted in accordance with IMO requirements.

BPD = barrels per day

3.1.3. Marine Geology/Sediments and Marine Benthos

The drilling of wells and the placement of flowlines and other subsea equipment will physically disturb approximately 0.7 square kilometers (km^2) (0.3 square miles [mi^2]) of the sea bottom. After the initial structural casing section is installed, the remaining NADF drill cuttings will be returned to the drill ships for treatment to remove associated drilling fluids prior to discharge to the sea in order to meet acceptable discharge thresholds. The planned discharge of NADF drill cuttings will result in a localized accumulation of cuttings on the seafloor, primarily around the drill center locations, with the distribution of deposition determined by oceanographic conditions. Modeling has indicated that the discharge of these cuttings will not significantly impact sediment quality because of the relatively low toxicity and expected dispersion. Overall, the Project impact on marine sediments will be **Negligible**.

Marine benthos (organisms living on the seafloor) could also be impacted by Project-related seafloor disturbance by potential smothering from the drill cuttings. The most sensitive component of the benthic community to elevated TSS concentrations is immobile taxa living on the hard seafloor features in the PDA. While the mortality rate of immobile taxa individuals from physical disturbance resulting from installation of the subsea infrastructure will be high, the population is not anticipated to be sensitive to the reduction in individuals within the limited area affected. Therefore, the significance of potential impacts on marine benthos due to FPSO and SURF installation is considered **Negligible**.

The presence and eventual abandonment of subsea infrastructure would constitute an irreversible loss of natural, soft, bottom habitat within the collective footprint of these structures, but some species of benthos may colonize this hard substrate or be attracted to it as an artificial reef. The addition of small amounts of hard substrate will likely increase the diversity of the local benthic community as species that require hard substrate colonize the area where none existed before, but it also results in the loss of soft substrate that will continue to be unavailable within

the footprint of the subsea infrastructure. These effects will occur over a small area of the PDA. The net effect of converting a small portion of the PDA from soft to hard bottom throughout production operations and decommissioning stages and beyond would be **Positive**.

3.1.4. Seabirds (including Special Status Species)

Seabirds have the potential to be impacted by planned Project activities through attraction- and disturbance-related effects or collision with a Project vessel or helicopter. It was determined that the significance of these residual impacts range from **Negligible** to **Minor** (for seabirds as a whole and special status seabirds) for the reasons explained below.

The EEPGL-commissioned marine bird survey completed from 2017 through 2020 indicated that the seabird community offshore Guyana is moderately diverse, but the abundance of birds is low compared with other areas in the greater Caribbean and tropical Western Atlantic region. The Project could impact seabirds by acting as an attractant to seabirds because of its lighting; or exposing them to disorientation, collision risks, additional energy expenditure, and compromised navigation for night-migrating birds. The Project lighting will be downcast when feasible to minimize its attraction potential. Potential benefits from the Project to seabirds are use of the FPSO, drill ship, and installation vessels for rest or shelter during adverse weather conditions or during long migrations and, if such vessels act as consistent attractants for seabird prey, providing a reliable food resource for seabirds.

Two special status species, Leach's Storm-Petrel (*Oceanodroma leucorhoa*) and Black-capped Petrel (*Pterodroma hasitata*) are known to occur in the Project Area of Influence (AOI), although only Leach's Storm-Petrel was observed during marine bird surveys conducted from 2017 through 2020. Leach's Storm-Petrel will have the same significance of potential impacts as non-special status seabirds, namely, **Negligible** to **Minor**. For Black-capped Petrel (which is the only seabird listed as Endangered), the significance of potential impacts from Project activities was also considered **Negligible** to **Minor**, based on the small size and declining population trend of this species and the duration of the production operations stage of the Project (20 years).

3.1.5. Marine Fish (including Special Status Species)

Marine fish survey conducted between 2017 and 2020 indicates that deepwater fish diversity is poor in the vicinity of the PDA and the pelagic fish community is typical of the region. The data suggest that offshore pelagic fish may be slightly more abundant in the latter half of the year, while nearshore fish are more abundant and diverse during the rainy season when freshwater inputs to the estuaries are greatest. The Project could impact marine fish by deterioration of water quality from the discharges described above, acoustic effects, and the potential to entrain (suck in) fish at the cooling water intake. Modeling indicates that water quality will return to near background conditions within 100 meters (approximately 328 feet) of the FPSO, so the area impacted will be very small, and fish are mobile and are known to avoid areas with degraded water quality. Water intakes will be designed to minimize the entrainment of fish. Several special status marine fish species are known or thought to occur in the Project AOI. The significance of

potential residual impacts on marine fish was considered to be **Negligible** to **Minor**, or for some special status offshore marine fish species, **Moderate**.

3.1.6. Marine Mammals (including Special Status Species)

Marine mammals have the potential to be impacted by the planned Project activities, primarily as a result of exposure to underwater sound, and it was determined that the significance of these potential residual impacts ranges from **Negligible** to **Minor**. Marine mammal observations recorded during surveys in and around the Stabroek Block since 2015 indicate that the marine mammal community in the Stabroek Block consists primarily of small cetaceans, and that large cetaceans (i.e., whales) rarely occur south of the Stabroek Block on the relatively shallow continental shelf. Marine mammals have the potential to be impacted by two types of sound from planned Project activities: continuous sound from vessels and machinery operating in the PDA; and comparatively louder, shorter-duration impulse sound from Vertical Seismic Profiling (VSP). Both the continuous sound and impulsive sound sources would be loud enough to cause injury in the immediate vicinity of the source but would attenuate to non-injurious levels within approximately 9 meters (approximately 30 feet) from the vessels and approximately 73 meters (approximately 240 feet) from the VSP.

Based on the premise that marine mammals will actively avoid physical discomfort associated with Project-related sound, mid-frequency cetaceans (MFCs) would be expected to generally avoid the portion of the water column within at least approximately 700 meters (2,297 feet) from the location where pile driving is taking place, and low-frequency cetaceans (LFCs) would be expected to generally avoid the portion of the water column within at least approximately 1,400 meters (approximately 4,600 feet) of the activity. Both categories of cetaceans would be expected to avoid these areas for the duration of the pile-driving activity. LFC species, including many of the larger baleen whales and dolphins, and some MFC species, including toothed whales, will naturally remain outside of the area of potential effect because it will be deeper than their deepest recorded dive depths. Some MFC species, such as sperm whales, dive much deeper than LFC species (approximately 1,200 meters [approximately 4,000 feet] in tropical and subtropical latitudes), but most species do not dive deep enough or remain at depths long enough that they could potentially be exposed to injurious sound levels within the PDA.

3.1.7. Riverine Mammals (including Special Status Species)

Two species of riverine mammals—the American manatee (*Trichechus manatus*) and the neotropical otter (*Lontra longicaudis*)—have the potential to be impacted by planned Project activities as a result of increased Project vessel traffic within the Demerara Harbour. Manatees and neotropical otters occur in low numbers in the brackish/intertidal waters of the Demerara Harbour and lower Demerara River, but resident riverine mammals of the harbor are expected to be habituated to the constantly changing and human-influenced environments of the harbor. The slight increase in overall marine vessel traffic in Georgetown Harbour that will occur as a result of the Project (2 to 4 percent increase) may result in a slight incremental increase in temporary avoidance behavior and displacement from the vessel transport route, which itself

represents a small portion of the available riverine habitat within the harbor, but it was determined that the significance of this potential residual impact was **Minor**.

3.1.8. Marine Turtles (including Special Status Species)

Marine turtles have the potential to be impacted by planned Project activities, but it was determined that the significance of these potential residual impacts is **Negligible**. Marine turtles are generally considered to be less sensitive to marine sound than marine mammals, so underwater sound from Project activities would not have the same potential to impact marine turtles as marine mammals. Marine turtles have been detected at a much lower rate than marine mammals offshore Guyana during surveys conducted from 2015–2020, which suggests that the density of marine turtles offshore is comparatively low. Preliminary tracking data from a marine turtle telemetry study initiated as part of the Liza Phase 1 Development Project indicate that individual turtles may nest multiple times a season at Shell Beach and that during the period between nesting events, they generally remain close to the nesting beaches, which would reduce the probability of their being disturbed by Project vessel traffic moving within the PDA or between the PDA and shorebases in Guyana. The Project would be located more than 200 kilometers (126 miles) offshore. At this distance, the offshore activities currently envisioned as part of the Project would have little to no likelihood of affecting nesting activities, which occur at the coast.

3.1.9. Ecological Balance and Ecosystems

All planned Project activities that could affect the physical or biological attributes of the Project AOI are broadly relevant to basic ecosystem functions such as nutrient cycling, gene flow, and maintenance of biodiversity. The significance of potential residual impacts on ecological balance and ecosystems was concluded to be **Minor**. Changes in water quality could affect the planktonic base of the marine food web, but based on the **Negligible** to **Minor** significance of water quality impacts and the very small portion of the North Brazil Shelf Large Marine Ecosystem that will be exposed to these impacts, the Project is predicted to have little if any measurable ecosystem-level impacts on nutrient cycling. The Project is not expected to create any significant obstacles to migration, breeding, or dispersal/colonization, so Project-related residual impacts on gene flow are expected to be **Negligible**. Ballast water exchange during the production operations stage is predicted to have potential impacts on biodiversity due to the potential for introduction of exotic or invasive species, but embedded controls will limit the potential for this impact (and the extent of the impact if it were to occur) and it is not expected to lead to the loss of any species or other long-lasting biological effects within the North Brazil Shelf Large Marine Ecosystem. Therefore, the Project's residual impacts on maintenance of biodiversity are expected to be **Minor**.

3.1.10. Employment and Livelihoods

As discussed above, the Project will generate a variety of marine vessel trips throughout the Project life (at least 20 years) and these will potentially impact open-ocean shipping in the

vicinity of the PDA, the limited commercial fishing activity that occurs as far out as the PDA, and commercial and subsistence fishing activity within the portion of the Direct AOI that connects the PDA to Georgetown Harbour. In addition to the potential impacts on commercial and subsistence fishing vessels navigation, there may be potential impacts on livelihoods of artisanal fisherfolk nearshore and industrial fishing vessel operators in remote offshore areas as a result of navigation impacts. While commercial fishing vessels offshore will lose access to some fishing areas that are currently available to them as far out as the PDA, the significance of this potential residual impact on commercial fishing livelihoods was assessed as **Negligible** considering the small number of operators that currently participate in deep-sea fishing (no more than 12 vessels), the small footprint that will be impacted in the PDA, and the ability to provide information in advance about EEPGL's operations and marine safety exclusion zones. The highest potential for Project interactions with fisherfolk may be encounters with support vessels transiting between the PDA and shorebases in Georgetown. This could result in some limited and temporary disruption to mostly artisanal fishing activity in these areas. Artisanal fisherfolk engaging in fishing on the Guyanese coast have a limited ability to adapt to potential disruption to subsistence fishing activities, and since many do not carry radios, may use remote ports, and/or may not receive notices of increased vessel activity, the significance of this potential residual adverse impact on artisanal fishing livelihoods was assessed as **Minor**. Overall, the potential impacts on employment and livelihoods that will result from Project employment, procurement, and worker spending are considered to be **Positive**.

3.1.11. Community Health and Wellbeing

The key potential impacts on community health and wellbeing as a result of planned Project activities are increased risk of communicable disease transmission, decreased public safety as a result of the presence of Project workers, increased public anxiety concerning the oil and gas industry as a whole, and decreased availability of emergency medical and health services. Given the small size of the Project workforce in comparison with the receiving community (less than 1 percent of the population of Georgetown), the Project workers' limited and occasional onshore presence, and the embedded health controls in place to further reduce risk, the significance of potential residual impacts related to both communicable disease transmission and public safety are considered **Negligible**. The residual significance of public anxiety over oil and gas sector risks, especially among the more vulnerable populations along the coastal areas in Region 1, is assessed to be **Minor**. In Georgetown, where there are higher levels of literacy and multiple means of accessing information on the Project and the country's developing oil and gas sector on a continual basis, anxiety and misconceptions about Project risks are considered to be **Negligible**. The potential for reduced access to emergency and health services as a result of Project activities, even considering a Project-dedicated onshore medical provider and ambulance, is assessed to have a **Minor** residual significance, principally in relation to the population in Georgetown and the vicinity, considering existing health system gaps.

3.1.12. Marine Use and Transportation

The Project will generate a variety of marine vessel trips throughout the Project life (at least 20 years), including maritime transport of Project materials, supplies, and personnel as well as the presence of the FPSO, drill ships, and major installation vessels. These marine activities will potentially impact vessel traffic into and out of Georgetown Harbour, open-ocean shipping in the vicinity of the PDA, the limited commercial fishing activity that occurs as far out as the PDA and commercial and subsistence fishing activity within the portion of the Direct AOI that connects the PDA to Georgetown Harbour. Project-related traffic is expected in both the active commercial port and in international waters, and commercial vessels are expected to be able to safely navigate around other vessels. Therefore, the significance of potential residual impacts on commercial cargo vessels in Georgetown Harbour and in the vicinity of the PDA is considered to be **Negligible**. Commercial fishing vessels offshore will lose access to some fishing areas that are currently available to them and will have to avoid Project-related vessel traffic where none currently exists. Subsistence fishing vessels will not lose access to existing fishing areas, as subsistence fishing does not occur as far out to sea as the PDA. Subsistence fishing vessels could experience interference due to movements of Project-related vessel traffic. While Notices to Mariners will be provided to mitigate potential interference with commercial and subsistence fishing vessel navigation, there are limitations—in particular for subsistence vessels—to the effectiveness of these notices. Accordingly, the significance of potential residual impacts on commercial and subsistence fishing vessels navigation as a result of increased marine traffic is assessed as **Minor**.

3.1.13. Social Infrastructure and Services

The planned Project activities with the potential to impact social infrastructure and services include Project worker presence (with the potential to impact availability of lodging and the availability and/or cost of housing and utilities) and ground and air transportation (with the potential to increase traffic congestion). Although the Project will have limited onshore planned activities, the presence of Project workers and of those seeking Project-related work has the potential to increase demand for housing and utilities in the Georgetown area, where current shortfalls of housing and appropriate utilities infrastructure already exist. While the anticipated number of Project workers is insignificant (less than 1 percent) compared to the Georgetown population, the significance of the potential residual impact (decreased availability/increased cost of housing and utilities) is assessed as **Minor** during the drilling and installation stages—when the workforce is at its peak. Due to smaller numbers of Project workers anticipated during the production operations stage, the residual impact significance is assessed as **Negligible** for this stage.

The presence of Project workers also has the potential to increase demand for lodging in the Georgetown area, which may lead to reduced availability and/or increased cost. While an assessment of available lodging in Georgetown indicates minimal chance for capacity constraints, due to the anticipated number of Project workers requiring lodging, the potential residual impact is assessed as **Minor** during the drilling and installation stages—when the

workforce requiring lodging is at its peak. Due to smaller numbers of Project workers anticipated during the production operations stage, the residual impact significance is assessed as **Negligible**.

Planned Project activities will generate additional vehicular traffic around Georgetown as a result of EEPGL-related personnel movements and non-personnel (e.g., equipment, supplies, etc.) movements. Traffic impact modeling confirmed that the additional EEPGL-related vehicle trip counts in 2026 will not meaningfully change traffic congestion levels on the road segments across Georgetown anticipated to potentially be among the more heavily used by EEPGL-related vehicle movements. On this basis, the significance of potential residual impacts on ground transportation as a result of planned Project activities is considered to be **Minor**.
The level of helicopter activity associated with the Project is unlikely to meaningfully impact Eugene F. Correira International Airport's heliport capacity or operations, and the impact significance to air transportation is considered to be **Negligible**.

3.1.14. Waste Management Infrastructure Capacity

The planned Project activities have the potential to impact waste management infrastructure capacity for current users of Georgetown-based hazardous waste treatment facilities (primarily other oil and gas operators) and non-hazardous waste landfills (primarily the general community) due to increased burden of Project wastes on the capacity of these facilities. However, since 2019, there has been a substantial expansion of third-party commercial hazardous waste handling, storage, and treatment facilities in Georgetown.

In addition, the construction of a second cell at the Haags Bosch Landfill (HBL) was completed during summer 2021. Continued upgrades and improvements at the HBL are ongoing. There remain two additional cells at the landfill available for future development. Each cell could extend the landfill capacity by 5 to 6 years, indicating that landfill capacity appears reasonable for the next 10 years. Subsequent decisions as to further expansion of existing or new municipal waste landfills will be undertaken by the Government of Guyana with the input and support of the Ministry of Local Government and Regional Development and the EPA and participation of the public and other stakeholders.

The projected Project waste generation represents a significant portion of the total demand for Georgetown-based hazardous waste treatment facilities. However, EEPGL's contributions of non-hazardous solid waste volumes sent to the HBL have been averaging approximately 6 to 7 percent of the total annual volume received by the facility.

Although the Project itself is not considered a receptor for the purpose of the EIA, the viability of its operations depends on reliable access to waste management infrastructure of a sufficient quality and with sufficient capacity. In view of this need to ensure Project viability, and in recognition of the potential future capacity constraints and potential impacts on non-Project users of Georgetown-based waste management infrastructure, the Project has initiated the following mitigation measures:

- As warranted based on anticipated future EEPGL hazardous waste generation trends and trends in non-EEPGL hazardous waste generation, continue enabling the expansion of existing local waste management capacity for hazardous wastes, and explore use of new local hazardous waste treatment facilities, or identify suitable alternative solutions.
- Continue monitoring of plans for further expansion of the HBL and/or (if approved by the EPA) construction of additional landfill sites in other locations (as decided by the government), or identify suitable alternative (interim) local solutions for non-hazardous waste management.

In addition to these mitigation measures, EEPGL will implement a number of waste management-related embedded controls, in accordance with a Comprehensive Waste Management Plan covering management of all wastes that will be generated by the Project. Implementation of these mitigation measures and embedded controls will reduce the effects of Project-related demands on waste management infrastructure capacity, particularly related to hazardous waste management, resulting in a residual impact significance rating of **Negligible** for this aspect.

However, in view of the fact that capacity expansions for the Georgetown-based landfill facilities are not under EEPGL's control, the significance rating for potential residual impacts on Georgetown-based landfill capacity is maintained at a level of **Minor**.

3.2. UNPLANNED EVENTS

An unplanned event is defined as an event that is not planned to occur as part of the Project (e.g., oil spills, accidents), but that could potentially occur. Since these events are not planned, they are evaluated using methods different from those used for planned events, specifically taking into consideration the likelihood that an unplanned event will occur. For purposes of the Project, five types of unplanned events were identified and considered: hydrocarbon spill; discharge of untreated wastewater from the FPSO; vessel strike of a marine mammal, marine turtle, riverine mammals, or seabird; seabird collision with the FPSO flare tower, flare, or radiant heat plume; and vessel collision or onshore vehicular accident.

3.2.1. Vessel Collisions or Vehicular Accidents

While a vessel collision or vehicular accident could result in injuries, the potential for a vessel collision that led to significant injury or fatality would be expected to be low considering the robust controls incorporated into the Project, and the likely vessel and vehicle speeds in areas where risk of collisions would be highest. Based on consideration of the likelihood of occurrence and the likely range of severity given these factors, vessel collisions are considered to have a residual risk level of **Minor** and vehicular accidents (i.e., related to the community health and wellbeing resource) are considered to have a residual risk level of **Minor to Moderate**.

3.2.2. Vessel Strikes of Marine Mammals, Marine Turtles, or Riverine Mammals

While marine mammals possess acute senses of hearing that they can use to detect approaching vessels, and they have the necessary swimming speed capability to avoid collisions, they are vulnerable to vessel strikes when they surface to breathe or to feed. This vulnerability increases in shallow nearshore areas where opportunities to maneuver are reduced.

Marine turtles tend to spend most of their time at sea at or near the sea surface, and do not possess the acute sense of hearing or the swimming speed that cetaceans use to avoid collisions. Marine turtles are inherently more vulnerable to vessel strikes in the shallow nearshore areas, where they congregate prior to coming ashore to nest, than they are in the open ocean. This increased vulnerability is caused by higher concentrations of turtles in the shallow nearshore areas.

Riverine mammals likely to be present within the nearshore and riverine zone of the PDA are vulnerable to vessel collision when they surface to breathe or to feed. This vulnerability increases in shallow areas, where there are fewer opportunities to maneuver compared to the open ocean. The American manatee, in particular, would be susceptible to vessel collision within the lower Demerara River. It is well documented that manatees are highly vulnerable to vessel collision, and vessel collision is listed by the International Union for Conservation of Nature (IUCN) as one of the key threats to this subpopulation of manatees.

Most Project activities will take place in deep waters, and vessel speeds within the PDA will be low, reducing the potential for collisions. The only planned nearshore activities will be supply vessels entering/exiting shorebases, but even at the peak of drilling and installation, the incremental increase in traffic near shorebases will represent a small increase in overall risk to marine mammals and marine turtles. There is very little potential for collisions to occur within the PDA, but the potential remains for individual marine mammals or marine turtles to collide with vessels transiting between the PDA and shorebases. With respect to risk to marine turtles, the planned shorebases are all located more than 100 kilometers (62.1 miles) away from the nearest portion of the Shell Beach Protected Area, where most marine-turtle nesting in Guyana occurs (and where turtles may aggregate pre- and post-nesting as suggested by tagging data). With respect to riverine mammals, collision between a Project vessel and an American manatee could cause injury or mortality to the affected individual or temporary behavioral changes, but manatees in this area are accustomed to the presence of vessels and are therefore expected to exhibit some level of avoidance behavior when vessels are passing through. Very few manatees are expected to occur in the lower Demerara River, so vessel collision with a manatee, if it were to occur, would be very infrequent.

EEPGL will provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals and riverine mammals at the sea surface and will issue standing instructions to Project-dedicated vessel masters on what to do if they encounter marine mammals, marine turtles, or riverine mammals while in transit (i.e., reduce vessel speed or deviate from course, when possible, to lower the probability of a collision). While these

measures will serve to reduce the residual risk, the risk rating for a vessel collision is considered to be **Moderate** for marine mammals and marine turtles and **Minor** for riverine mammals.

3.2.3. Discharge of Untreated Wastewater from the FPSO

The FPSO will be equipped with an onboard sewage treating system, which will treat black water prior to discharge overboard. While there will be a number of controls to prevent a discharge of untreated black water to the ocean, an upset to this treatment system lasting for an extended period could result in untreated black water being discharged overboard for a short period of time. While there are a number of controls that would prevent this scenario from occurring, modeling of the scenario was conducted to assess the risk associated with such an event. Modeling results show that the short-term release of untreated wastewater will result in a plume of limited extent with maximum concentrations of biochemical oxygen demand, TSS, and coliform remaining below the International Maritime Organization standards, yielding a residual risk rating of **Minor** for all potentially affected resources.

3.2.4. Seabird Collision with FPSO Flare Tower, Flame, or Radiant Heat Plume

The FPSO will have a flare system for the collection and safe disposition of associated hydrocarbon gases resulting from unplanned, non-routine maintenance or repairs, or emergency shutdown events. Should flaring occur, the flame and radiant heat plume will emanate from a flare tower located on top of the FPSO. While individual seabirds could be significantly impacted through contact with the FPSO flare tower, its flame, or its radiant heat plume, the likelihood of a seabird colliding with the tower or being present in the heat zone when temporary, non-routine flaring is occurring is extremely low. While this does not preclude the possibility of a flock to occur, it is considered relatively rare, and any such flocks would likely be small. Even during migration, most individuals are solitary or flying in loose groups (spread out spatially). Accordingly, in the circumstance that such an event occurred, it would likely only impact a single individual, yielding a risk rating of **Minor**.

3.2.5. Oil Spill

The Project will be producing, processing, storing, and offloading oil as its core activity, so the risk of an oil spill would be present. EEPGL has identified 16 spill scenarios, including spills of different types of hydrocarbons (e.g., crude oil, marine diesel, fuel oil, lubricating oil, NADF), with several being applicable for spills at the shorebases and on vessels in the Demerara River estuary (e.g., from a supply vessel) or in the Atlantic Ocean (e.g., from a well, drillship, supply vessel, tanker, FPSO). The largest of these scenarios considered a loss-of-well-control incident at the seafloor. For these scenarios, EEPGL worked with third-party specialists to model two WCD scenarios for a loss-of-well-control event. The following discussion summarizes the impacts from these largest spill scenarios; see EIA Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events, for a full discussion of all spill scenarios and their resultant impacts.

The WCD scenarios were developed based on a request from the Department of Energy regarding the Liza Phase 2 Project Development Plan. In accordance with the Department of Energy's request, EEPGL commissioned a third party to develop WCD calculations for the reservoirs to be developed as part of the Project in accordance with the U.S. Bureau of Safety and Environmental Enforcement's (BSEE's) guidelines published in the U.S. Department of Interior BSEE Worst Case Discharge Analysis (Volume I, February 2016). As stated in the BSEE guidelines document, although WCD modeling results "present an extremely dire representation of the potential for contact between the discharged oil and the environment, they do provide a working baseline of datum that will be useful for further analysis" (BSEE 2016).

The U.S. Bureau of Ocean Energy Management defines the WCD as the single highest daily flow rate of liquid hydrocarbon during an uncontrolled wellbore flow event (i.e., the average daily flow rate on the day that the highest rate occurs, under worst-case conditions). The WCD values represent an open well condition in which *no flow restrictions or well-control technologies* such as blowout preventers are in operation. The WCD is neither the total volume spilled over the duration of the event, nor the maximum possible flow rate that would result from high-side reservoir parameters. It is a single value for the expected flow rate calculated under worst-case wellbore conditions using expected reservoir properties. The main purpose of a WCD calculation is to support oil spill response planning. The duration of the WCD release is typically 30 days unless shutting in the well with a capping stack or other technology is expected to occur earlier.

The third-party specialist incorporated information for the six reservoirs to be developed as part of the Project into its WCD simulation program and calculated six reservoir-specific WCDs ranging from 25,151 to 202,192 BPD (4,024.2 to 32,359.7 m^3). In consultation with EEPGL's oil spill modeling contractor, RPS, EEPGL identified two WCD scenarios to model a potential Project well-control scenario with loss of containment. These two scenarios were selected to characterize uncontrolled wellbore flows for Project reservoirs with varying characteristics. EEPGL contracted with RPS to model two WCD scenarios for the Project. The 88,728 BPD (14,196.5 m^3) loss-of-well-control scenario is the highest of the calculated WCD rates (and therefore would be expected to produce similar modeling results), so this scenario was modeled as the "Most Credible WCD." EEPGL also selected a 117,157 BPD (18,745.1 m^3) loss-of-well-control scenario to be modeled as the "Maximum WCD." Although modeling of the Maximum WCD scenario supports oil spill response planning, the scenario represents an operational condition that is highly unlikely to be encountered during drilling operations. In a more representative scenario, apart from blowout preventers on the wellhead, there would be drill string, tubing, and/or other equipment that would be in the wellbore during a well-control event, which would partially constrain and restrict flow from the reservoir.

EEPGL's well-control philosophy is focused on blowout prevention using safety and risk management systems, management of change procedures, global standards, and trained experienced personnel. EEPGL has a mature program that emphasizes attention to safety, well control, and environmental protection. This includes proper preparation for wells (e.g., well design, well-control-equipment inspection and testing), detecting changes in pressure quickly,

and efficiency in the process for temporary closing of a well (personnel training and proficiency drills).

In addition to these prevention measures, EEPGL also has developed a detailed Oil Spill Response Plan (OSRP) to ensure an effective response to an oil spill, if one were to occur. The OSRP identifies the organizations that would respond to a release event depending on the magnitude and complexity of the spill. The OSRP clearly delineates the responsibilities of each entity that would take part in a response and describes how EEPGL would mobilize both its own resources and those of its oil spill response contractors, as well as notifying the government of Guyana with respect to mobilizing its resources.

Due to the precautionary measures proposed by EEPGL to prevent and control an oil spill, as described above, the chance of an oil spill occurring is unlikely. Nevertheless, EEPGL has conducted oil spill modeling and coastal sensitivity mapping to identify and characterize the resources/receptors with the potential to be exposed to oil in the unlikely event of a spill. An overview of this modeling and mapping is provided below.

The spill modeling evaluated the range of possible trajectories and rate of travel of an oil slick from each of the two above-referenced loss-of-well-control scenarios. Several factors would inherently reduce the severity of an oil spill occurring in the PDA and would increase subsequent ecosystem recovery rates, including the following:

- Location of Spill—A Yellowtail loss-of-well-control incident would occur approximately 203 kilometers (approximately 126 miles) offshore. It would take some time for oil to reach the Guyana shoreline, which allows time to implement the Project's OSRP, and also allows more time for evaporative and dispersive forces to act on the spilled material.
- Prevailing Currents—The Guiana Current is a strong, nearly year-round westerly flowing current along the coast of Guyana. The SAT-OCEAN current model used in the oil spill modeling analysis is based on the Hybrid Coordinate Ocean Model that includes three-dimensional current speeds in a 4°×4° grid over the Stabroek Block region (56°-60°W, 7°-11°N). The horizontal resolution of the model is 1/64°, and the model defines current speed and direction on 64 vertical layers through the water column. The time series data set defines three-dimensional currents at a 3-hour interval for the 10 years between 2005 and 2014. The data from the SAT-OCEAN current model were calibrated by current data measured at a location offshore Guyana (8.08°N, 56.95°W) during 2015. Considering the extent of the historical record and calibration with measured data, these data are appropriately representative of the region and are expected to capture expected variability in the current forcing. Modeling indicates that this current significantly reduces the probability of spilled oil reaching the coast of Guyana; however, this effect also increases the probability of an oil spill impacting the coastal zones of nearby countries to the north and west.
- Properties of Spilled Oil—The Project will be producing a medium crude oil. Medium crude oils exhibit greater evaporation and lower emulsification and are less persistent in the environment than heavy crude oils. These qualities make the oil readily amenable to oil spill

response strategies such as chemical dispersion and in-situ burning, which are appropriate and highly effective in this offshore environment. This medium crude is also amenable to more traditional oil spill response strategies such as mechanical booming and recovery.

- Climate—The relatively warm year-round waters of the AOI would keep any spilled oil less viscous, which helps clean-up operations such as skimming and pumping.

The modeling predicted that surface oil would generally travel towards the northwest in all scenarios during both the June through November and December through May seasons. A type of modeling known as stochastic modeling was performed for a number of spill scenarios. Stochastic modeling accounts for the variability in conditions such as winds and ocean currents by simulating hundreds of individual spills (theoretically occurring at different times and under different wind/current conditions) and generating a map that is a *composite* of all of the trajectories and provides a *probability footprint* showing the most likely path that a spill would follow. Stochastic modeling of an unmitigated subsea release of crude oil from a loss-of-well-control event indicates that even in the unlikely event of an oil spill, there is a 5 to 40 percent chance of the oil contacting the coast in Region 1, and a 5 to 10 percent probability of the oil reaching Region 2. It is important to note that this stochastic modeling does not account for any oil spill response (e.g., aerial, vessel, or subsea dispersant application; offshore containment and recovery; source control operations), so any preventative measures taken to keep oil from reaching the coast during a response would further reduce the potential of shoreline oiling in Guyana below the estimated 5 to 40 percent.

In addition to the low probability of oil reaching the Guyana shoreline (even in the absence of any spill response), stochastic modeling indicates it would take 5 to 10 days (depending on WCD scenario and actual wind and current conditions) for oil to reach the Guyana shoreline. This would allow ample time for mobilization of spill response resources to further reduce the risk of oil actually reaching the shoreline. Despite this, if oil were to reach the Guyana shoreline, those resources most at risk would include protected areas (i.e., Shell Beach), coastal habitats (especially mangroves and marshes), and coastal wildlife (especially birds), as well as coastal communities and Indigenous Peoples dependent on fishing in the ocean and other ecosystem services (Table EIS-4).

To assess the potential magnitude of impacts in the unlikely event of an oil spill, the 95th percentile spill event for shoreline stranding by oil with a thickness greater than 1 micrometer was selected from each stochastic scenario in the June through November and December through May seasons, and deterministic modeling was conducted for each of these scenarios. This deterministic modeling resulted in a prediction of the sea surface area swept by oil and the length of shoreline oiled with a thickness greater than 1 micrometer, assuming no implementation of response measures. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain offshore of Guyana for the Most Credible WCD scenario in all seasons and for the Maximum WCD scenario from June through November. Deterministic modeling predicts impact across most of the Region 1 coast for December through May for a Maximum WCD spill. Modeling of a mitigated Maximum WCD scenario indicates that mitigation would reduce the length of shoreline impacted compared to an unmitigated scenario, but most

of the Region 1 shoreline would be affected. The deterministic modeling analysis does not predict shoreline impacts in Guyana outside of Region 1 for either the Most Credible WCD or Maximum WCD scenarios, regardless of season or the effects of mitigation.

To aid in preparing to respond to the unlikely event of an oil spill, coastal sensitivity maps were prepared for the entire Guyana coastline, and the coastlines of 11 other countries for which modeling indicates a potential risk of shoreline oiling due to an unmitigated release. To provide additional detail to these maps, ecosystem services mapping was conducted for Regions 1 through 6. In Regions 1 and 2, the Guyana regions that could be directly affected by a spill resulting from an unmitigated loss-of-well-control event, provisioning services (focused on fishing, agriculture, hunting, and traditional resource use) and regulating services (associated with mangroves' role in stabilizing and protecting the coast) were key ecosystem services identified and field-verified.

The combination of the low probability of an oil spill actually reaching the Guyana shoreline and the time available to allow for spill response results in the residual risk to coastal resources being considered **Minor** to **Moderate** (Table EIS-4). If an oil spill were to reach the coast during the migratory or breeding season for coastal birds or the mudflats that these species use to feed, the impacts could be significant. The ecosystem services component of the coastal sensitivity mapping also highlighted the role that the coastal habitats within the Shell Beach Protected Area play in sustaining marine fisheries on the western Guyana continental shelf, and the importance of ecosystem services to sustaining the coastal communities along the entire coast, and particularly in the Amerindian communities of Region 1.

Table EIS-4: Coastal Resources Potentially Impacted by an Oil Spill

Resource	Potential Impact	Residual Risk Rating
Protected Areas	Shell Beach Protected Area and its vicinity could be impacted if oil were to reach the Guyana shoreline.	Moderate
Coastal Habitats and Coastal Wildlife (including Special Status Species)	Mangroves, wetlands, and mudflats are common habitats along the Guyana coastline that support many wildlife species, particularly coastal birds. These habitats and species are sensitive to oil contamination.	Minor to Moderate
Ecosystem Services, Coastal Communities and Indigenous Peoples	Many rural coastal communities, and especially indigenous communities, rely on many ecosystem services (e.g., for food, housing materials, medicinal plants, income producing products, flood protection) for sustenance and livelihoods, and for social and cultural practices.	Minor

Even though the probability of a spill is very low, such an oil spill would likely have adverse impacts on marine resources in the area impacted by the spill. Those resources most at risk would be marine water quality, seabirds, marine mammals, and marine turtles, as described in Table EIS-5. Although effective implementation of the OSRP would help mitigate this risk by further reducing the ocean surface area impacted by a spill and oil exposure to these species, the residual risk to all of these resources aside from marine mammals and seabirds as a whole is considered **Moderate**. In the case of Leach's Storm-Petrel, the offshore PDA is a migratory

corridor for a relatively large number of this species. Accordingly, the residual risk to Leach's Storm-Petrel from an oil spill is considered **Moderate**.

Table EIS-5: Marine Resources Potentially Impacted by an Oil Spill[2]

Resource	Potential Impact	Residual Risk Rating
Marine Water Quality	Dissolution of some spilled oil into the water column, but light oil expected to degrade quickly, and the impacts are reversible.	Moderate
Seabirds (Non-special Status Species)	Seabirds are typically among the species most impacted by an oil spill because they spend significant time on the water surface and so may come in contact with the spilled oil, but seabirds are primarily transient in the PDA.	Minor [a]
Leach's Storm-Petrel (*Oceanodroma leucorhoa*) (Special Status Species)	The nature of the impact on Leach's Storm Petrel is the same as for (nonspecial status) seabirds as a whole. However, the residual risk rating for this species is considered **Moderate** based on the results of the marine bird post-permit study, which documented the importance of the offshore zone as a migratory corridor for this particular species.	Moderate
Marine Mammals	Ingestion and respiratory irritation from inhalation of vapors at the water surface, and the potential for fouling of baleen whale plates, which are used to feed.	Minor
Marine Turtles	Dermal irritation from contact with oil, ingestion, and respiratory irritation from inhalation of vapors at the water surface.	Moderate

[a] Excludes Leach's Storm-Petrel, which is discussed separately

3.3. TRANSBOUNDARY IMPACTS

Oil spill modeling indicates that transboundary impacts could potentially occur for the three largest spill scenarios considered (2,500-barrel [400 m^3] FPSO offloading spill, and the two loss-of-well-control scenarios), assuming no mitigation measures were implemented. The modeling results for these scenarios indicate there is the potential for an unmitigated oil spill to reach three main geographic regions:

- Trinidad and Tobago, the northern South American coast, and the so called "ABC Islands" (Aruba, Bonaire, and Curaçao);
- The southern Lesser Antilles; and
- The Greater Antilles.

An unmitigated oil spill from either of the loss-of-well-control events during the December through May season would take a west-northwesterly route through the Gulf of Paria and across the southern edge of the Caribbean Sea. Comparatively strong easterly winds in the December through May season would expose the northern coast of South America, the ABC Islands, and the southern Lesser Antilles to the bulk of shoreline oiling risk. An equivalent spill during the June through November season would be exposed to lower wind speeds, allowing the surface

[2] Residual impacts of a marine oil spill on marine fish would be less severe than on other marine biological receptors because of limited pathways to exposure to surface slicks, active avoidance, and the expectation that dispersed oil would be rapidly diluted to very low concentrations in open-water environments.

plume to be transported to the north of Trinidad and Tobago and swept into the Caribbean Sea. The plume would track slightly more to the north, across the central Caribbean Sea and the central and southern portions of the Lesser Antilles, to the Greater Antilles. This more northerly track would pose less risk to western Venezuela and the ABC Islands and more risk to the north-central Lesser Antilles and Greater Antilles, although eastern Venezuela would still be at risk of shoreline oiling from a loss-of-well control event in the June through November season.

Mitigated oil spills from each of the two loss-of-well-control scenarios would only have the potential to reach Venezuela and Trinidad and Tobago and would reduce the extent of shoreline oiling associated with spills under both scenarios relative to the corresponding unmitigated spill.

3.3.1. Trinidad and Tobago and the Northern South American Coast, including Aruba, Bonaire, and Curaçao

Due to its location at the southern end of the Lesser Antilles, Trinidad and Tobago has the highest probability of any of the Antillean islands of shoreline oiling as a result of a loss-of-well-control event. The probability of oiling at least a portion of the coast of Trinidad and Tobago and/or its coastal waters is approximately 10 to 100 percent for the unmitigated Most Credible WCD scenario scenarios. The lower end of this probability range increases slightly for a loss-of-well-control event in the last half of the year, yielding a 20 to 100 percent probability of shoreline oiling under the Maximum WCD scenario. The highest probabilities of oiling occur on exposed, southern- and eastern-facing shorelines under both scenarios. With the exception of the Gulf of Venezuela, stochastic modeling indicates a 5 to 90 percent probability of surface oil reaching the Venezuelan coastal zone. Probabilities of coastal oiling in Venezuela depend on scenario, location, and season, with the highest probabilities for the Maximum WCD scenario in eastern Venezuela from December through May.

Stochastic modeling suggests a 5 to 40 percent risk of shoreline oiling in the ABC Islands, with slight differences depending on island, season, and scenario. Aruba and Curaçao have a 5 to 20 percent and 10 to 40 percent risk of shoreline oiling respectively for both the Most Credible and Maximum WCD scenarios year-round. Bonaire would have a 10 to 20 percent chance of being oiled under the Most Credible WCD scenario in both seasons and under the Maximum WCD scenario from December through May, and a 10 to 40 percent chance of shoreline oiling under the Maximum WCD scenario from June through November. Deterministic modeling results are generally consistent with the stochastic modeling results for the Most Credible WCD scenario in summer but suggest no risk of shoreline oiling for any of the ABC Islands for the Most Credible WCD scenario in December through May or for either season under the Maximum WCD scenario.

Venezuela has numerous marine turtle nesting beaches, mangroves, Important Bird Areas (IBAs), coral reefs, and shallow coastal lagoons that would be at risk of oiling. The highest concentrations of most of these resources occurs in the Orinoco Delta in the eastern portion of country, although the corals and seagrasses tend to be more abundant surrounding offshore islands in the western portion of the country. The same types of resources tend to be found on Aruba, Bonaire, and Curaçao or their adjacent marine territories. Numerous fishing areas are

located east of Trinidad and could be impacted by a large unmitigated spill from a loss-of-well-control event. The economies of Aruba, Bonaire, and Curaçao are dependent on tourism to varying degrees but especially so in Bonaire, which is known internationally as a destination for recreational diving. The economic effects of an oil spill on these countries would depend to a large degree on the extent to which these industries would be affected, and how rapidly they would recover.

3.3.2. Southern Lesser Antilles

The Lesser Antillean countries north of Tobago that would be at risk of oil coming ashore from a loss-of-well-control event include Barbados, St. Vincent and the Grenadines, St. Lucia, and Grenada. The probability of nearshore waters in the southern Lesser Antillean region north of Tobago being affected by a spill varies widely according to location and season, from a 60 percent probability along the southern coast of Grenada in the June through November season for both the Most Credible WCD and Maximum WCD scenarios to a 5 to 10 percent probability across much of eastern St. Lucia and Martinique in both seasons and under both scenarios. Most of the western coasts of these countries would have little to no chance of being oiled. Barbados would only have a 5 to 10 percent probability of shoreline oiling under either scenario, and only in the June through November season.

3.3.3. Greater Antilles

The Greater Antilles would be exposed to the greatest risk of shoreline oiling during the June through November season, when comparatively weak trade winds would allow an oil plume to track further north than at other times of the year. A Most Credible WCD spill would be expected to reach Jamaica in the June through November season and the southern portion of the Dominican Republic in the December through May season. A Maximum WCD spill would be predicted to reach the coasts of the Dominican Republic and Haiti in the June through November season, but would be expected to track south of the Greater Antilles in the December through May season.

The portion of the Greater Antilles that could be affected by an unmitigated oil spill is notable for the number of protected areas it contains. These include:

- The Arrecifes de Suroeste (Southwest Reefs) Marine Sanctuary and Scientific Reserve in the Dominican Republic, which is an array of coral reefs and seagrass meadows located along the coast and is purported to support the American manatee, dolphins, and other marine mammals.
- Jaragua National Park in the Dominican Republic, which has terrestrial and marine components and has cultural significance due its numerous caverns that contain pictograms and petroglyphs from the Taino culture, as well as other pre-Columbian archaeological sites. The park is reported to support 130 bird species (10 of them are endemic), solenodons and hutias, as well as American manatees and bottlenose dolphins.

- The Portland Bight Protected Area (PBPA), which is the largest protected area in Jamaica. Its terrestrial area is 520 km^2 (201 mi^2) in the southern sections of St. Catherine and Clarendon parishes, including the coastline from east of Hellshire to almost Milk River in the west. It includes contiguous coastal land and the marine area out to the 200-meter (656-foot) depth contour (1 nautical mile, or approximately 2 kilometers south of Portland Point). It is a Ramsar wetland site, contains sandy beaches and cays which support nesting marine turtles, nesting seabirds), nearshore islands which support endemic lizards, and mangroves. Benthic marine resources in the PBPA include seagrass and coral reefs.
- The Black River Lower Morass, another wetland Ramsar site located approximately 15 kilometers (9 miles) west of the PBPA and Jamaica's largest wetland. It supports the IUCN-listed American crocodile (*Crocodylus acutus*) (Vulnerable) and is listed as an IBA by Birdlife International.

3.3.4. Impacts of International Importance

In addition to the country-specific impacts listed above, seabirds would have the potential to be affected at a regional scale. Since 2010, BirdLife International has focused its efforts on identifying Marine IBAs with specific significance to seabirds. There are 49 Marine IBAs of global or regional importance to seabirds that lie within the swept zone of a Maximum WCD unmitigated loss-of-well-control scenario (considering both seasons together). These sites contain regionally or globally important breeding and foraging sites for numerous species of seabirds, including species with elevated conservation status (i.e., IUCN listing status of Vulnerable or higher). Two of these 49 Marine IBAs that are located along the southern coastline of Hispaniola (Haiti and the Dominican Republic) are particularly significant as they support the world's only known breeding sites for Black-capped Petrel (*Pterodroma hasitata*) (IUCN Endangered).

3.3.5. Mitigation of Transboundary Impacts

The unmitigated oil spill modeling used to characterize potential transboundary impacts did not take into consideration any emergency response actions. Implementation of the OSRP would help to significantly reduce potential transboundary impacts just as it would reduce impacts within the Guyana Exclusive Economic Zone, as demonstrated by oil spill modeling that considers OSRP implementation (i.e., mitigated scenarios). In particular, EEPGL has put in place an interim solution that will facilitate installation of a capping stack on the well location. At the time the EIA was submitted, the response time associated with deployment of the capping stack system (specifically the Boots & Coots Global Rapid Intervention Package [GRIP] system) was based off preliminary and conservative logistics assumptions. After establishing the subscription to the Boots & Coots GRIP system, and in conjunction with an ongoing capping stack study, the response time model has been refined to reflect current logistics strategies and it is now estimated that the capping stack deployment is possible within 5.5 days.

Therefore, modeling for a mitigated loss-of-well-control scenario is based upon a 5.5-day installation of the capping stack at the well for the WCD scenarios and that timing is reflected in

the mitigated scenarios modeling. Mitigated scenario modeling demonstrates that this, in combination with other response measures (e.g., dispersant application), would significantly reduce the extent of transboundary impacts. In any case, EEPGL will work through the Ministry of Foreign Affairs, at the direction of the Government of Guyana, with representatives of the respective countries that could be potentially impacted by a large oil spill to be prepared for the unlikely event of a spill by:

- Coordinating operations and communications between different command posts;
- Creating a transboundary workgroup to manage waste from a product release, including identifying waste-handling locations in the impacted regions and managing commercial and legal issues (wastes collected in countries outside of Guyana will be handled according to the regulations required specific to that location);
- Identifying places of refuge in the impacted region where response vessels could go for repairs and assistance;
- Determining how EEPGL and the impacted regional stakeholders can work together to allow equipment and personnel to assist in a spill response outside the region while still retaining a core level of response readiness within the jurisdictions;
- Determining financial liability and establishing claims and/or livelihood remediation processes during a response to a transboundary event; and
- Working with local communities within the impacted areas to raise awareness of oil spill planning and preparations.

3.4. CUMULATIVE IMPACTS

The Project's expected contribution to cumulative impacts to many resources will be limited by its distance offshore, by the distance between EEPGL projects/activities, and by the small number of non-EEPGL projects or activities either operating or currently planned to be operating offshore Guyana. There are other offshore and onshore Guyana oil and gas exploration and development activities planned or in operation by EEPGL, including the operating Liza Phase 1 Development, the approved Liza Phase 2 Development, and Payara Development projects, continued exploration drilling, two other future planned development projects in the Stabroek Block (assumed to be located in the eastern part of the Stabroek Block, near prior exploration wells with discoveries), a fiber optic cable installation project, an onshore Guyana Office Campus, and the Gas to Energy Project—a project which is expected to transport associated gas from the Liza Phase 1 PDA to shore for creation of natural gas liquids and natural gas power production (gas from the Yellowtail Project is currently not planned to be transported to shore as part of the Gas to Energy Project). Additionally, there is a limited number of non-oil and gas related projects proposed by others that could potentially impact the same types of resources that could be impacted by the Project. Three other oil and gas operators are planning exploration programs in blocks adjacent to the Stabroek Block, but the current schedules for these efforts and their locations are such that they would not be expected to overlap in time or geographically with Project activities.

The Project activities, other planned EEPGL activities, and non-EEPGL activities together could cumulatively impact some resources such as air quality and climate (via increased emissions of GHGs and other pollutants), marine water quality (via discharge of drill cuttings and associated increases in TSS concentrations), special status fish (via changes in distribution due to altered water quality), special status seabirds (via attraction to offshore facilities or disturbance from Project activities), marine mammals (via vessel strikes), special status marine turtles (via vessel strikes), marine fish (via degraded water quality), riverine mammals (via behavioral changes or displacement as a result of increased vessel traffic within Georgetown Harbour), ecological balance and ecosystems (via introduction of invasive species via ballast water discharges, changes in marine nutrient cycle resulting in localized and temporary changes in phytoplankton species distribution, and impacts on gene flow), community health and wellbeing (via increased demand on limited medical treatment capacity), marine use and transportation (via additional marine congestion, especially near Georgetown Harbour), socioeconomic conditions (via potential cost of living increases and competition for workers, but positive benefits from increased government revenues, employment, and local business activity), employment and livelihoods (via interference with artisanal fishing activities, but positive benefits to employment, business, and incomes in Georgetown and vicinity), social infrastructure and services (via increased demand for limited housing and lodging), and waste management infrastructure capacity (via increased burden on waste treatment or disposal facilities in Georgetown). Many of the above potential impacts that require offshore interaction between the Project and others to result in a cumulative impact have a limited chance of occurring, given the size of the Stabroek Block.

The Project will adopt a number of embedded controls, mitigation measures, and management plans. These are considered sufficient to address the contributions of the Project to cumulative impacts. With respect to the contributions of multiple EEPGL projects/activities to potential cumulative impacts, it is recommended that EEPGL, when designing and undertaking these additional projects/activities, ensure that the same level of potential impact management (i.e., as for the Yellowtail Project) be implemented. In addition, with the intention of minimizing the potential interactions between effects of multiple projects, it is recommended that EEPGL take measures, where feasible and practicable, to share logistical resources between development projects—to reduce the number of additional vessel movements associated with additional projects. This approach would be expected to be sufficient to address contributions of the Project and other EEPGL projects/activities to cumulative impacts on marine mammals and marine turtles.

Regarding climate, EEPGL plans to develop a flare minimization plan for the Yellowtail Development Project, as well as committing to continue measuring and reporting its GHG contributions to national emissions. In addition, a key strategy integrated in the FPSO design to reduce the frequency and duration of non-routine flaring for upsets and maintenance on the compression system will be the inclusion of installed spare gas compression equipment capacity. During instances where one compression unit is offline for upset or maintenance, installed spare compression equipment can be used to allow partial or full production to continue while reducing volume and duration of flared gas. The gas compression sparing

capacity provided in the Yellowtail Project design exceeds that included in the designs of prior EEPGL development project FPSOs. It is recommended that EEPGL continue to assess measures that can be taken to minimize GHG emissions during the Project's production operations stage and ensure that an assessment is undertaken on an as-needed basis to assess effectiveness of embedded controls and mitigation measures selected to reduce GHG emissions. In the case of waste management infrastructure capacity, the mitigation measures already initiated by EEPGL and progress being made toward expanding capacity of local waste management infrastructure represent appropriate collaborative efforts with industry and government to manage the cumulative impacts on this resource.

3.5. DEGREE OF IRREVERSIBLE DAMAGE

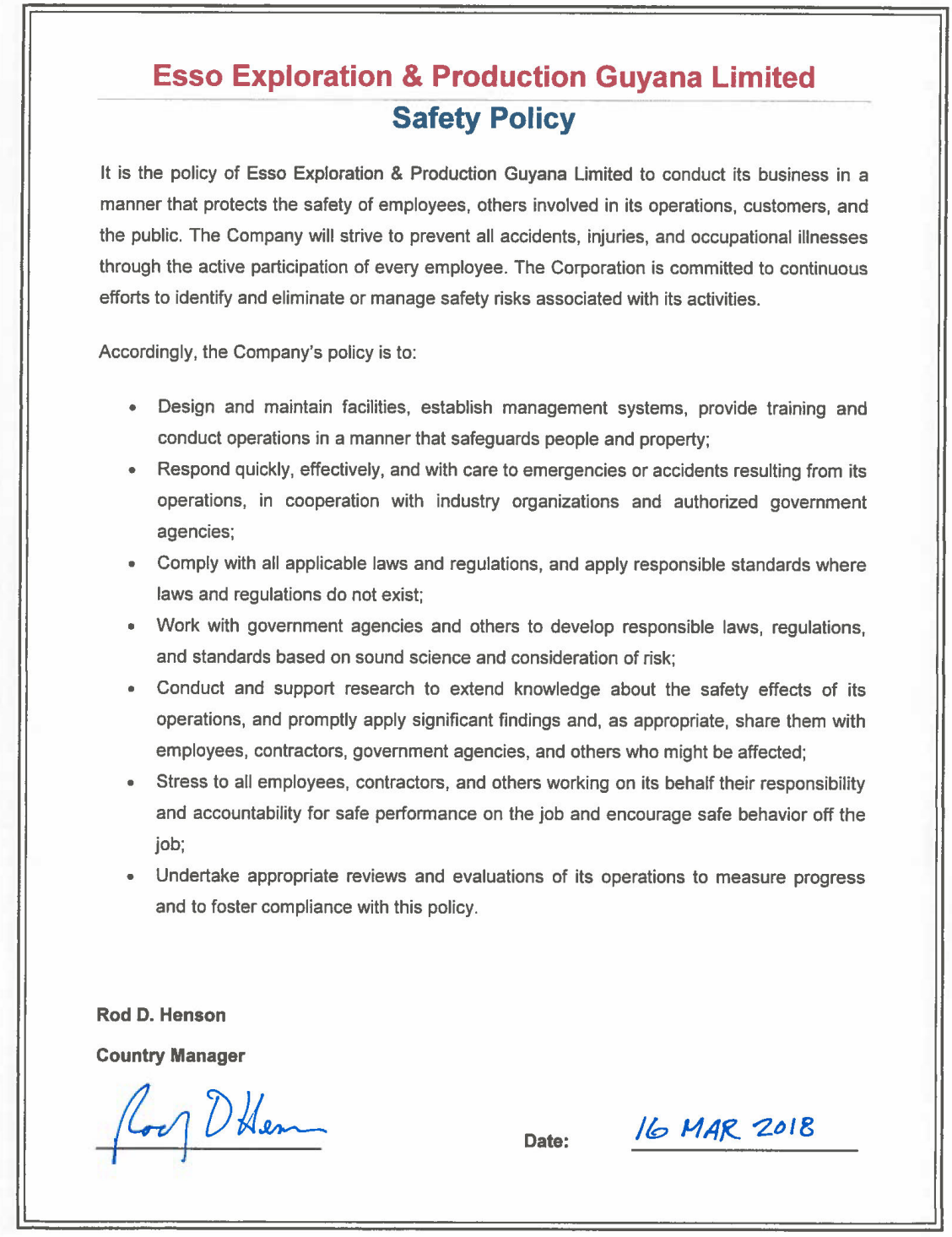
The planned Project would not cause irreversible damage to any onshore areas of Guyana. There would be a very minor (approximately 0.7 km^2 [0.3 mi^2]) permanent loss of benthic habitat offshore as a result of the installation of wells, flowlines, and other subsea equipment, which may be proposed to be left in place upon decommissioning. However, this equipment can ultimately provide the substrate for recolonization of the impacted areas. Even in the unlikely event of a large marine oil spill, little irreversible damage would be expected, although it could take a decade or more for all resources to fully recover, depending on the volume and duration of the release, as well as the time of year at which the release were to occur.

3.6. MANAGEMENT PLANS

A series of management plans has been developed to manage and mitigate the impacts identified in the EIA. This series includes the following:

- Environmental and Socioeconomic Management Plan Framework
- Environmental Management Plan, including:
  - Air Quality Management
  - Water Quality Management
  - Marine Ecosystems Management
- Socioeconomic Management Plan, including:
  - Stakeholder Engagement Plan
  - Grievance Management
  - Marine Transportation Management
  - Road Transportation Management
  - Cultural Heritage Management and Chance Finds
- Environmental and Socioeconomic Monitoring Plan
- Emergency Response Plan Summary
- Oil Spill Response Plan, including:
  - Oil Spill Modeling
  - Net Environmental Benefit Analysis
  - Wildlife Response Plan
  - Geographic Strategic Response Maps
- Preliminary End of Operations Decommissioning Plan

EEPGL's Safety, Security, Health, and Environment Policies are provided here as Figures EIS-7 through EIS-10, respectively.



Esso Exploration & Production Guyana Limited

Safety Policy

It is the policy of Esso Exploration & Production Guyana Limited to conduct its business in a manner that protects the safety of employees, others involved in its operations, customers, and the public. The Company will strive to prevent all accidents, injuries, and occupational illnesses through the active participation of every employee. The Corporation is committed to continuous efforts to identify and eliminate or manage safety risks associated with its activities.

Accordingly, the Company's policy is to:

- Design and maintain facilities, establish management systems, provide training and conduct operations in a manner that safeguards people and property;
- Respond quickly, effectively, and with care to emergencies or accidents resulting from its operations, in cooperation with industry organizations and authorized government agencies;
- Comply with all applicable laws and regulations, and apply responsible standards where laws and regulations do not exist;
- Work with government agencies and others to develop responsible laws, regulations, and standards based on sound science and consideration of risk;
- Conduct and support research to extend knowledge about the safety effects of its operations, and promptly apply significant findings and, as appropriate, share them with employees, contractors, government agencies, and others who might be affected;
- Stress to all employees, contractors, and others working on its behalf their responsibility and accountability for safe performance on the job and encourage safe behavior off the job;
- Undertake appropriate reviews and evaluations of its operations to measure progress and to foster compliance with this policy.

Rod D. Henson

Country Manager

Date: 16 MAR 2018

Figure EIS-7: Safety Policy

Esso Exploration & Production Guyana Limited

Security Policy

It is the policy of Esso Exploration & Production Guyana Limited to provide security and safeguards as needed to protect its personnel, assets, operations, facilities, and business information. Security is a line management responsibility. The vigilance and involvement of every employee and contractor is needed, as is a professional and technically competent security organization, Specific activities include:

- Compliance with relevant laws and regulations affecting security in areas where we operate. Where they do not exist, responsible standards based upon our worldwide experience will be applied.
- Systematic assessment of security risks, and ensuring they are managed through the application of protective measures which reflect best cost-effective practices.
- Special emphasis on personnel and protection and security in developing areas.
- Integration of security programs with Operations Integrity Management System (OIMS).
- Monitoring of potential risks through appropriate worldwide information sources and formulation of special steps required.
- Through effective partnerships with the businesses, integration of security measures in the early stages of new plans and projects.
- Prompt investigation of security breaches and irregularities, and provision of sound advice to management concerning steps to be taken.
- Appropriate reviews and evaluations of our security performance to measure effectiveness and drive continuous improvement.

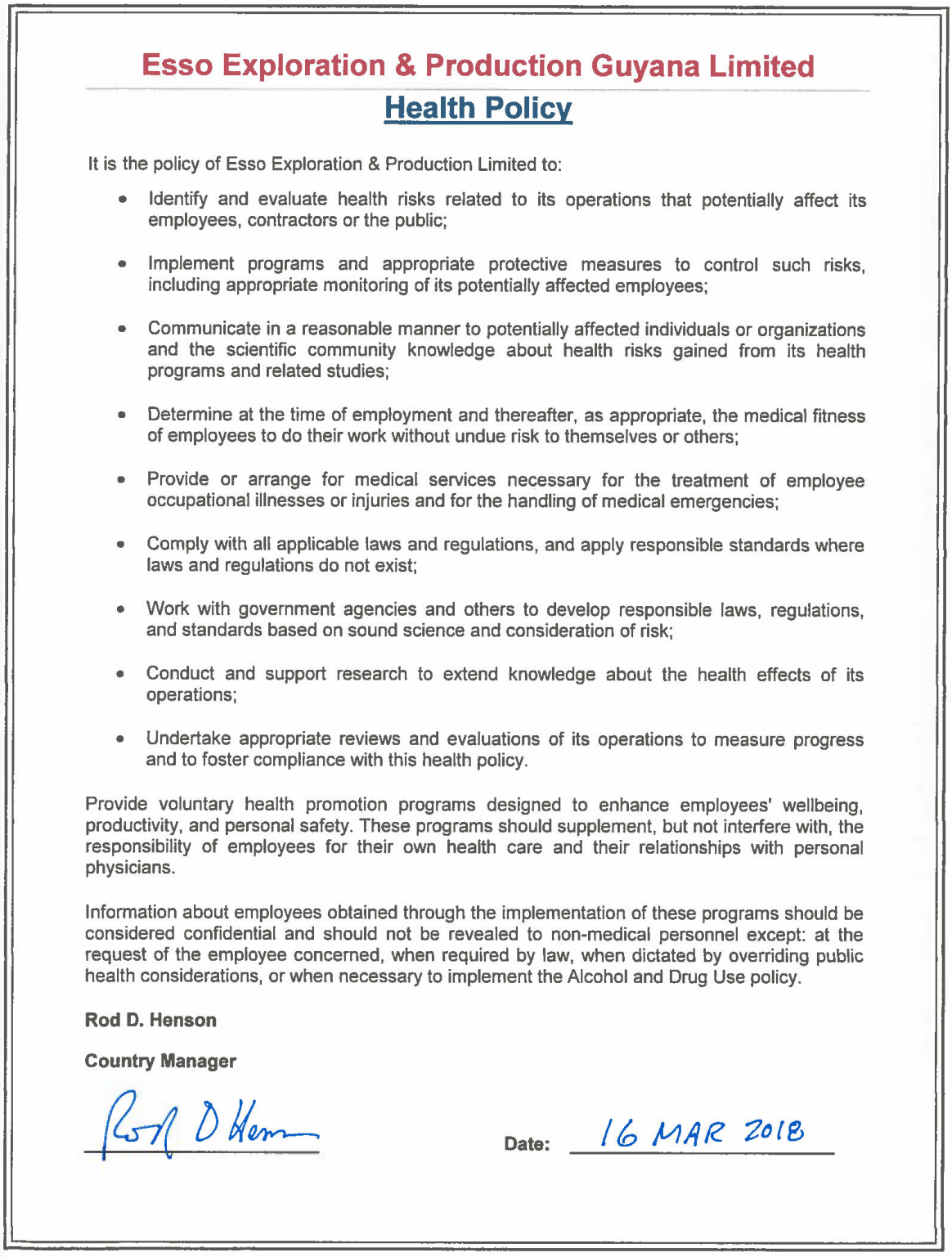
Rod D. Henson

Country Manager

Rod D Henson

Date: 16 MAR 2018

Figure EIS-8: Security Policy



Esso Exploration & Production Guyana Limited

Health Policy

It is the policy of Esso Exploration & Production Limited to:

- Identify and evaluate health risks related to its operations that potentially affect its employees, contractors or the public;
- Implement programs and appropriate protective measures to control such risks, including appropriate monitoring of its potentially affected employees;
- Communicate in a reasonable manner to potentially affected individuals or organizations and the scientific community knowledge about health risks gained from its health programs and related studies;
- Determine at the time of employment and thereafter, as appropriate, the medical fitness of employees to do their work without undue risk to themselves or others;
- Provide or arrange for medical services necessary for the treatment of employee occupational illnesses or injuries and for the handling of medical emergencies;
- Comply with all applicable laws and regulations, and apply responsible standards where laws and regulations do not exist;
- Work with government agencies and others to develop responsible laws, regulations, and standards based on sound science and consideration of risk;
- Conduct and support research to extend knowledge about the health effects of its operations;
- Undertake appropriate reviews and evaluations of its operations to measure progress and to foster compliance with this health policy.

Provide voluntary health promotion programs designed to enhance employees' wellbeing, productivity, and personal safety. These programs should supplement, but not interfere with, the responsibility of employees for their own health care and their relationships with personal physicians.

Information about employees obtained through the implementation of these programs should be considered confidential and should not be revealed to non-medical personnel except: at the request of the employee concerned, when required by law, when dictated by overriding public health considerations, or when necessary to implement the Alcohol and Drug Use policy.

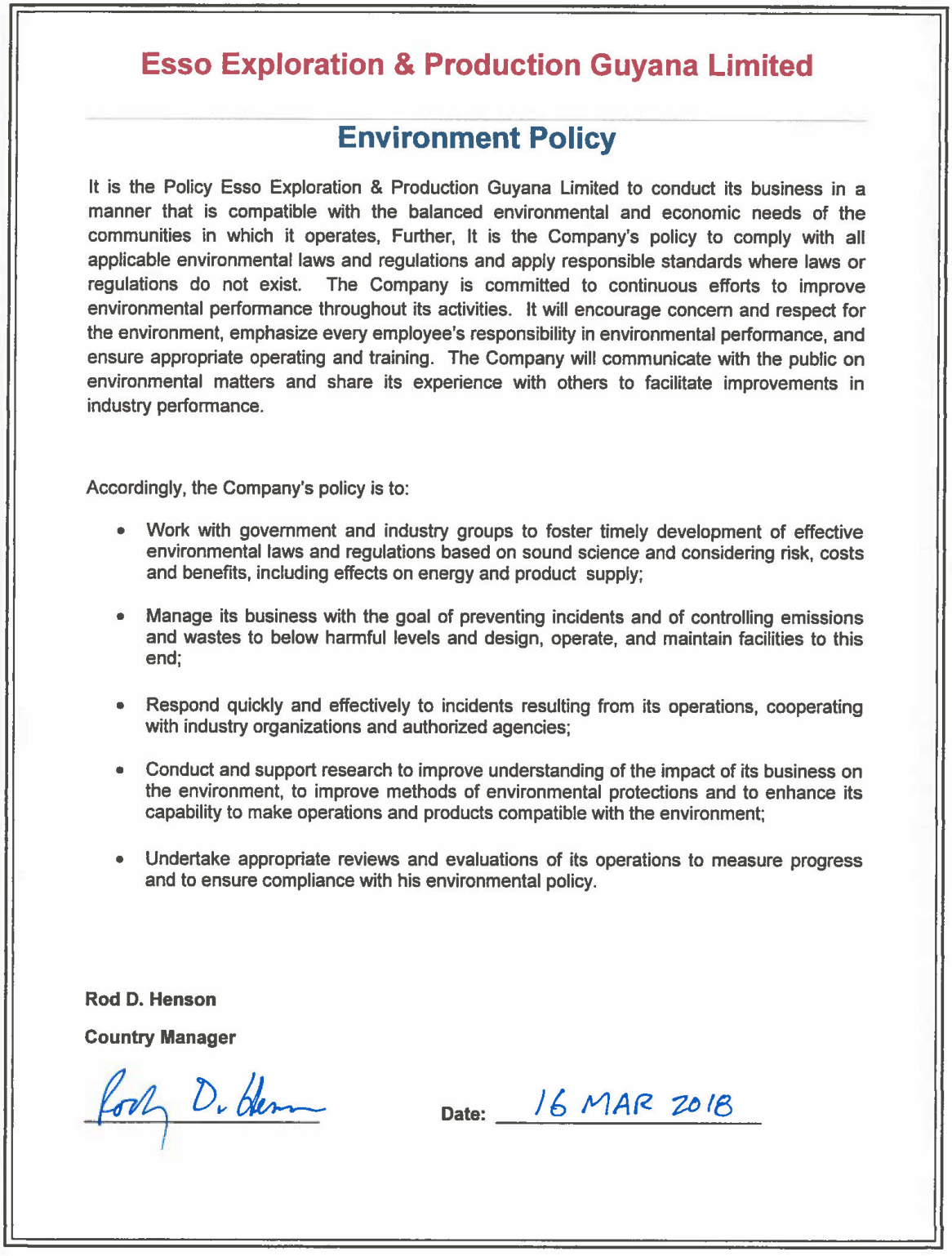
Rod D. Henson

Country Manager

Rod D Henson

Date: 16 MAR 2018

Figure EIS-9: Health Policy



Esso Exploration & Production Guyana Limited

Environment Policy

It is the Policy Esso Exploration & Production Guyana Limited to conduct its business in a manner that is compatible with the balanced environmental and economic needs of the communities in which it operates, Further, It is the Company's policy to comply with all applicable environmental laws and regulations and apply responsible standards where laws or regulations do not exist. The Company is committed to continuous efforts to improve environmental performance throughout its activities. It will encourage concern and respect for the environment, emphasize every employee's responsibility in environmental performance, and ensure appropriate operating and training. The Company will communicate with the public on environmental matters and share its experience with others to facilitate improvements in industry performance.

Accordingly, the Company's policy is to:

- Work with government and industry groups to foster timely development of effective environmental laws and regulations based on sound science and considering risk, costs and benefits, including effects on energy and product supply;
- Manage its business with the goal of preventing incidents and of controlling emissions and wastes to below harmful levels and design, operate, and maintain facilities to this end;
- Respond quickly and effectively to incidents resulting from its operations, cooperating with industry organizations and authorized agencies;
- Conduct and support research to improve understanding of the impact of its business on the environment, to improve methods of environmental protections and to enhance its capability to make operations and products compatible with the environment;
- Undertake appropriate reviews and evaluations of its operations to measure progress and to ensure compliance with his environmental policy.

Rod D. Henson

Country Manager

Rody D. Henson Date: 16 MAR 2018

Figure EIS-10: Environment Policy

A number of environmental and socioeconomic performance criteria will be used by the Project. These performance criteria are consistent with good international oilfield practice. Table EIS-6 presents a summary of those key environmental and socioeconomic performance criteria the Project will utilize which have a specific quantitative standard.

Table EIS-6: Summary of Key Environmental and Socioeconomic Performance Criteria with Specific Quantitative Standards to be used by the Project

Aspect	Performance Criteria to be Applied	International Standard That References Applied Performance Criteria
Bilge Water	Comply with requirements, including treatment of bilge water in accordance with the International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) to comply with an oil in water content of less than 15 parts per million as applicable.	MARPOL 73/78
Cooling Water	Avoid increases in ambient water temperature of more than 3ºC (5.4ºF) at 100 meters (~328 feet) from the point of discharge.	World Bank Group Environmental Health and Safety (EHS) Guidelines for Offshore Oil and Gas Development
Drilling Fluids and Cuttings—NADF	Use solids control and cuttings dryer systems to treat cuttings such that, for discharged cuttings, end of well maximum weighted mass ratio averaged over all well sections drilled using non-aqueous base fluid does not exceed 6.9 percent wet weight base fluid retained on cuttings.	World Bank Group EHS Guidelines for Offshore Oil and Gas Development
Food Waste	Comminute to 25-millimeter-diameter particle size or less and comply with requirements.	MARPOL 73/78
Produced Water	Treat to achieve an oil in water content of 29 mg/L (monthly average) and 42 mg/L (daily maximum).	World Bank Group EHS Guidelines for Offshore Oil and Gas Development

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. CONCLUSIONS

The planned Project activities are predicted to have **Negligible** to **Moderate** residual impacts on physical resources (i.e., air quality and climate, marine geology and sediments, marine water quality), no impacts on coastal biological resources, **Negligible** to **Moderate** (and some positive) residual impacts on marine biological resources, and **Negligible** to **Minor** residual impacts on socioeconomic resources—with largely positive impacts on socioeconomic conditions and employment. These predictions are due to the fact that the bulk of the Project will occur approximately 203 kilometers (approximately 126 miles) offshore; and the Project will capture and re-inject recovered natural gas (the portion that is not used as fuel on the FPSO) into the reservoir, treat all effluent streams as required prior to discharge to the sea, have a very small physical footprint (e.g., installation of infrastructure will only physically disturb about 0.7 km^2 (0.3 mi^2) of benthic habitat), and use Marine Mammal Observers and "soft starts" during VSP operations to reduce the potential for auditory damage to marine animals. The Project will generate benefits for the citizens of Guyana through revenue sharing with the Government of Guyana, a minor increase in employment and in-country Project purchasing from Guyanese businesses.

Unplanned events, such as a potential oil spill, are considered unlikely to occur because of the extensive preventative measures employed by EEPGL; nevertheless, an oil spill is considered possible. The types of resources that would potentially be impacted and the extent of the impacts on those resources would depend on the volume and duration of the release, as well as the time of year at which the release were to occur, but impacts would tend to be most significant for a well-control event with loss of containment during the drilling stage. EEPGL has conducted oil spill modeling to evaluate the range of likely spill trajectories and rates of travel. The location of the Project 203 kilometers (approximately 126 miles) offshore, prevailing northwest currents, the medium nature of the Yellowtail and Redtail field crude oil, and the region's warm waters would all help reduce the severity of a spill. Accounting for these factors, modeling of an unmitigated subsea release of crude oil from an unmitigated loss-of-well-control event indicates a less than 5 percent to 40 percent probability of oil reaching the Guyana coast, without taking into consideration the effectiveness of any oil spill response, and in the unlikely event that a spill were even to occur.

Although the probability of an oil spill reaching the Guyana coast is small, an unmitigated subsea release of crude oil from a loss-of-well-control event at a Yellowtail well could impact coastal habitats and protected areas. A spill would likely impact any marine resources found near the well—which could include marine turtles, marine mammals, and seabirds that may transit or inhabit the area impacted by a spill, as well as marine water quality and marine sediments. Other physical and biological resources such as air quality, marine fish, and marine benthos could also be impacted, although likely to a lesser extent because the duration of acute impacts would not be long, and the impacts are reversible. A spill could potentially impact Guyanese fisherfolk if commercial fish and shrimp resources were impacted. The magnitude of

this impact would depend on the volume and duration of the release as well as the time of year at which the release were to occur (e.g., whether a spill would coincide with the time of year when these resources are more abundant in the PDA). Effective implementation of the OSRP would reduce this risk by reducing the ocean surface area impacted by a spill and thereby reducing the exposure of these resources to oil.

Additional unplanned events, also considered unlikely to occur because of the preventative measures employed by EEPGL, could include collisions between Project vessels and non-Project vessels; Project vessel strikes of marine mammals, marine turtles, riverine mammals, or rafting seabirds; collisions between Project vehicles and non-Project vehicles; onshore vehicular accidents; and a release of untreated wastewater from the FPSO. The extent of the impacts from these types of events would depend on the exact nature of the event. However, in addition to reducing the likelihood of occurrence, the embedded controls that EEPGL has or will put in place (e.g., training of vessel operators to recognize and avoid marine mammals, riverine mammals, and marine turtles; adherence to international and local marine navigation procedures; adherence to a Road Safety Management Procedure) would also serve to reduce the likely extent of impact, were such an event to occur.

Table EIS-7 provides a summary of the predicted residual impact significance ratings (taking into consideration proposed mitigation measures) for impacts on each of the resources that may potentially result from the planned Project activities in each Project stage (i.e., development well drilling and SURF/FPSO installation, production operations, and decommissioning). For each resource, the table shows the highest residual impact significance rating among the potential impacts relevant to each Project stage, as well as positive impacts. The table also summarizes, for each resource, the highest residual risk rating for potential risks to resources from unplanned events (e.g., oil spill, vessel strike, etc.) and the priority rating for potential cumulative impacts on each resource, as determined by the cumulative impact assessment.

Table EIS-7: Summary of Residual Impact Significance Ratings, Residual Risk Ratings, and Cumulative Impact Priority Ratings

Resource	Highest Residual Impact Significance Rating (Planned Project Activities)			Highest Residual Risk Rating (Unplanned Events)	Cumulative Impact Priority Rating
	Drilling and Installation	Production Operations	Decommissioning		
Air Quality, Climate, and Climate Change	Negligible	Moderate	Negligible	Minor	Low (Air Quality) Medium (Climate)
Sound [a]	None	None	None	None	NA
Marine Geology and Sediments	Negligible	None	None	Moderate	NA
Marine Water Quality	Minor	Negligible	Negligible	Moderate	Low
Protected Areas	None	None	None	Moderate	NA

Resource	Highest Residual Impact Significance Rating (Planned Project Activities)			Highest Residual Risk Rating (Unplanned Events)	Cumulative Impact Priority Rating
	Drilling and Installation	Production Operations	Decommissioning		
Special Status Species: [b]					
• Terrestrial species and coastal marine fish	Negligible	Negligible	Negligible	Minor	Low
• Vulnerable offshore marine fish	Minor	Negligible	Negligible	Minor	Low
• Critically Endangered and Endangered Offshore Marine Fish	Moderate	Negligible	Negligible	Minor	Low
• Near threatened seabirds and endangered black-capped petrel (*Pterodroma hasitata*)	Negligible	Minor [d]	Negligible	Minor	Low
• Vulnerable Leach's storm-petrel (*Oceanodroma leucorhoa*)	Negligible	Minor [d]	Negligible	Moderate [e]	Low
Coastal Habitats	None	None	None	Moderate	NA
Coastal Wildlife	None	None	None	Minor	NA
Seabirds [c]	Negligible	Minor	Negligible	Minor	NA
Marine Mammals	Minor	Minor	Negligible	Moderate	Medium
Riverine Mammals	Minor	Minor	Minor	Minor	Low
Marine Turtles	Negligible	Negligible	Negligible	Moderate	Low
Marine Fish [f]	Minor	Negligible	Negligible	Minor	Low
Marine Benthos	Negligible	Positive	Positive	Minor	NA
Ecological Balance and Ecosystems	Minor	Minor	Minor	Minor	Low
Socioeconomic Conditions (Guyanese Population):					
• Government revenues, employment, local business activity	Positive	Positive	Positive	Minor	Low
• Cost of living, competition for qualified workers	Minor	Minor	Minor	Minor	Low
Employment and Livelihoods:					
• Population of Georgetown and vicinity	Positive	Positive	Positive	Minor	Low
• Artisanal Fisherfolk	Minor	Minor	Minor	Minor	Low
Community Health and Wellbeing	Minor	Minor	Minor	Minor to Moderate	Low
Marine Use and Transportation:					
• Commercial cargo	Negligible	Negligible	Negligible	Minor	Low
• Commercial fishing	Minor	Minor	Minor	Minor	Low
• Subsistence fishing	Minor	Minor	Minor	Minor	Low

Resource	Highest Residual Impact Significance Rating (Planned Project Activities)			Highest Residual Risk Rating (Unplanned Events)	Cumulative Impact Priority Rating
	Drilling and Installation	Production Operations	Decommissioning		
Social Infrastructure and Services:					
• Lodging	Minor	Negligible	Negligible	Minor	Low
• Housing and utilities	Minor	Negligible	Negligible	Minor	Low
• Ground transportation	Minor	Minor	Minor	Minor	Low
• Air transportation	Negligible	Negligible	Negligible	Minor	Low
Waste Management Infrastructure Capacity	Minor	Minor	Minor	Minor	Medium
Cultural Heritage	Negligible	None	None	Minor	NA
Land Use	Negligible	Negligible	Negligible	Minor	NA
Ecosystem Services	None	None	None	Minor	NA
Indigenous Peoples	None	None	None	Minor	NA

NA = not applicable (not assessed in cumulative impact assessment); scoped out as potentially eligible (see EIA Chapter 10, Cumulative Impact Assessment)
[a] Potential underwater sound-related impacts on marine mammals, marine turtles, and marine fish are assessed in the resource-specific sections for those resources.
[b] Includes only seabirds and marine fish. Excludes listed marine turtles, listed marine mammals, and listed riverine mammals, which are covered in the Marine Turtles, Marine Mammals, and Riverine Mammals resource categories, respectively.
[c] Excludes listed seabirds, which are covered in the Special Status Species resource category.
[d] Based on the 20-year presence of the FPSO (as a lighted attractant), the potential impact significance to special status marine birds during the production operations stage is considered Minor.
[e] The residual risk rating for Leach's Storm-Petrel is considered Moderate based on the results of marine bird surveys in 2017, 2018, and 2019, which documented the importance of the offshore zone as a migratory corridor for this special status marine bird.
[f] Excludes listed marine fish, which are covered in the Special Status Species resource category

The Project will generate benefits for the citizens of Guyana in several ways:

- Through revenue sharing with the Government of Guyana, as detailed in the Petroleum Agreement between the Government of Guyana and EEPGL et al., which was made available to the public in December 2017. The type and extent of benefits associated with revenue sharing will depend on how decision makers in government decide to prioritize and allocate funding for future programs, which is unknown to EEPGL and outside the scope of the EIA.
- By procuring select Project goods and services from Guyanese businesses in alignment with the Petroleum Agreement and the EEPGL Local Content Plan updated by the Ministry of Natural Resources in June 2021.
- By hiring Guyanese nationals in alignment with the Petroleum Agreement and the EEPGL Local Content Plan.

In addition to direct revenue sharing, expenditures, and employment, the Project will also likely generate induced economic benefits. These induced benefits could result from the re-investment, hiring, and spending by Project-related businesses and/or workers, which in turn benefits other non-Project-related businesses and generates more local tax for the government.

These beneficial “multiplier” impacts are expected to occur throughout the Project life (at least 20 years).

4.2. RECOMMENDATIONS

The Consultants recommend the following measures be considered by the EPA, the Environmental Advisory Board, and other relevant Government of Guyana agencies as conditions of issuance of an environmental authorization for the Project:

- Embedded Controls—incorporate all of the proposed embedded controls (see EIA Chapter 13, Recommendations).
- Mitigation Measures—adopt the recommended mitigation measures (see EIA Chapter 13).
- Management Plans—implement the proposed Environmental and Socioeconomic Management Plan to manage and mitigate the potential impacts identified in the EIA.
- Oil Spill Preparedness—EEPGL has proactively embedded multiple controls into the Project design to prevent a spill from occurring, and we agree that a large spill that affects the Guyana coastline and/or other regional coastlines is unlikely. But given the sensitivity of many of the resources that could potentially be impacted by a spill (e.g., Shell Beach Protected Area; marine mammals; critically endangered, endangered, and vulnerable marine turtles; and Amerindian, fishing, and other communities reliant on ecosystem services for sustenance and their livelihood), we believe it is critical that EEPGL commit to regular oil spill response drills, simulations, and exercises—and involve appropriate Guyanese authorities and stakeholders in these activities, document the availability of appropriate response equipment on board the FPSO, and demonstrate that offsite equipment could be mobilized for a timely response.

With the adoption of such controls, mitigation measures, and management plans, and requirements for emergency response preparedness, the Yellowtail Development Project is expected to pose only minor risks to the environmental and socioeconomic resources of Guyana, while potentially offering significant economic benefits to the residents of Guyana.

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ENVIRONMENTAL IMPACT ASSESSMENT

1. INTRODUCTION AND PROJECT SCOPE

Esso Exploration and Production Guyana Limited (EEPGL) is seeking environmental authorization for a fourth development in the eastern half of the Stabroek Block. Hereafter referred to as the Yellowtail Development Project (or the Project), the Project will develop the Yellowtail and Redtail fields and potentially proximal resources. EEPGL is the designated Operator[1] of the Stabroek Block and is seeking authorization for the Project on behalf of itself and co-venturers Hess Guyana Exploration Limited and CNOOC Petroleum Guyana Limited. The objective of the Project will be to develop oil reserves from eastern half of the Stabroek Block. The area that will be developed as part of the Project is located approximately 203 kilometers (126 miles) northeast of the coastline of Georgetown, Guyana (Figure 1-1).

The Project scope includes drilling of approximately 45 to 67 development wells; installation and operation of Subsea, Umbilicals, Risers, and Flowlines (SURF) equipment; installation and operation of a Floating Production, Storage, and Offloading (FPSO) vessel; and ultimately, Project decommissioning.

The Guyana Environmental Protection Agency (EPA) has required EEPGL to conduct an Environmental Impact Assessment (EIA) in support of EEPGL's Application for Environmental Authorisation (Application) for the Project. Pursuant to section 11(4) of the Environmental Protection Act Cap 20:05, EEPGL has hired a team of qualified and independent environmental consultants, approved by the EPA, to conduct the EIA.

EEPGL has not yet made a Final Investment Decision on the Project, and is continuing to evaluate cost considerations during the Project development process. EEPGL has previously indicated the development cost for its third development in the eastern half of the Stabroek Block—the Payara Project—to be approximately $1.2 trillion GYD ($6 billion USD). For the purposes of the Yellowtail Development Project environmental authorization process, the Yellowtail Development Project development cost is estimated to be than $2.1 trillion GYD ($10.6 billion USD)[2], as the Project cost is anticipated to be higher than that of the Payara Development Project given the higher numbers of development wells and associated SURF and drilling costs.

[1] EEPGL will be the Operator of the Project, and is used in this Environmental Impact Assessment to represent the co-venturers.
[2] $1 U.S. dollar (USD) = $200 Guyanese dollars (GYD)

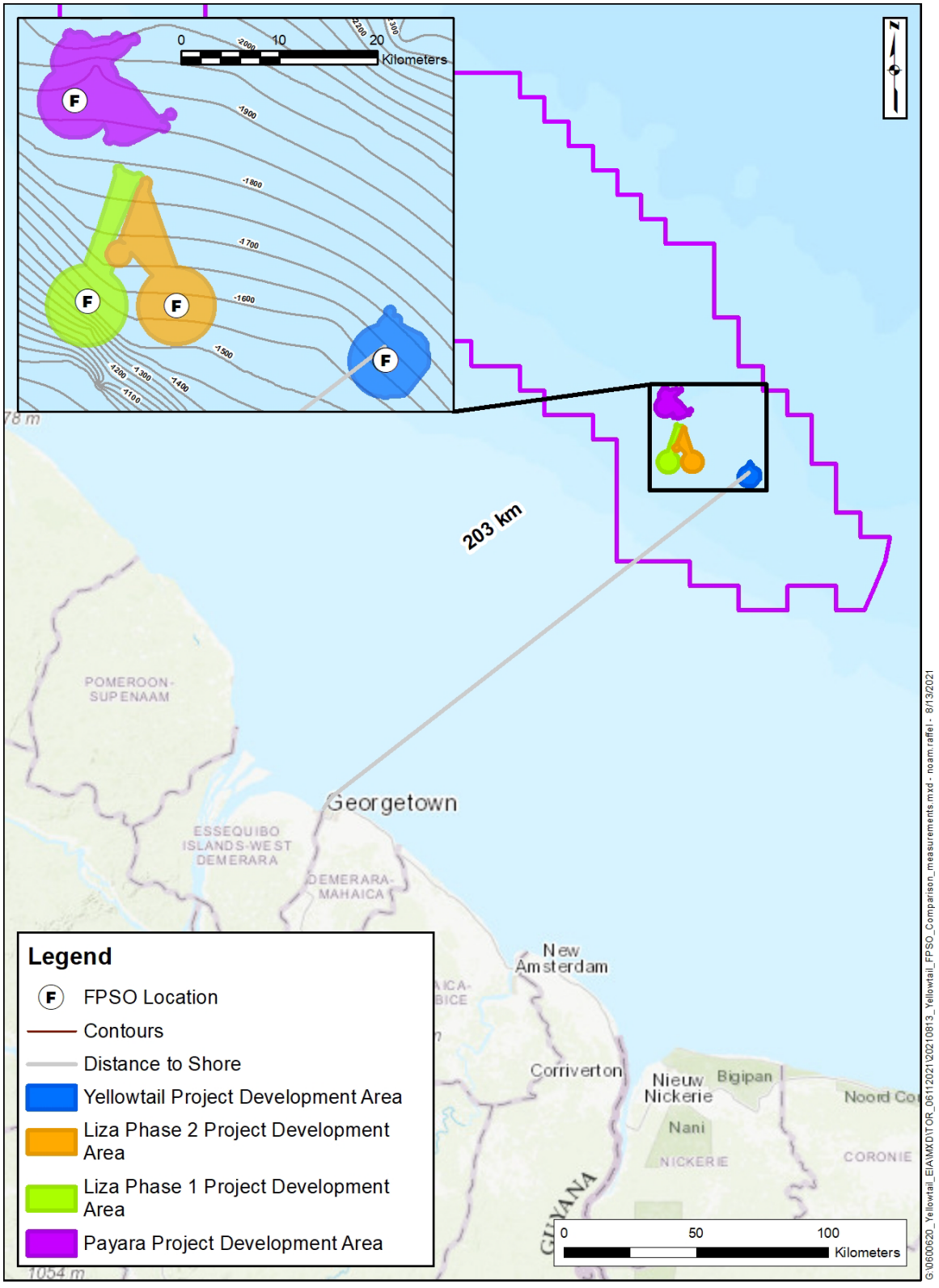


Figure 1-1: Location of the Yellowtail Development Project Development Area within Stabroek Block

1.1. PURPOSE OF THIS EIA

Guyanese law requires EEPGL to obtain an environmental authorization from the EPA to undertake the Project. The EPA oversees the effective management, conservation, protection, and improvement of the environment in Guyana. In this role, the EPA is responsible for managing the environmental authorization process. EEPGL filed an Application for Environmental Authorisation with the EPA on 1 April 2021. Based on an initial assessment of the Application, the EPA determined that an EIA was required in support of the Application.

The purpose of this EIA is to provide the factual and technical basis required for the EPA to make an informed decision on EEPGL's Application for Environmental Authorisation. After submission and review of this EIA, the EPA will take into account the review of other government agencies, the public's comments, EPA's own review—including support from technical experts, and recommendations from the Environmental Assessment Board (EAB) in deciding whether and under what conditions to grant EEPGL an environmental authorization for the Project. (An environmental authorization granted by the EPA is also commonly referred to as an environmental permit, and the two terms may be used interchangeably.)

The EAB is an independent body that contributes to the development and review of the EIA and makes recommendations to the EPA on whether the EIA should be accepted, amended, or rejected; whether the environmental authorization should be granted; and if so, under what terms and conditions. The EPA will also seek input on the EIA from other government agencies, including the Ministry of Natural Resources and the Guyana Geology and Mines Commission.

This EIA was prepared by a team of consultants including Environmental Resources Management (ERM), an international environmental and social consulting firm with a local registration in Guyana and extensive experience in the preparation of EIAs for offshore oil and gas development projects; SLR Consulting (SLR); and the Guyanese consultancies Caribbean Engineering & Management Consultants Inc. (CEMCO), The University of Guyana Centre for Study of Biological Diversity (CSBD), and Leon Moore Nature Experience (LMNE). ERM, SLR, CEMCO, CSBD, and LMNE are collectively referred to herein as "the Consultants." In a letter dated 28 June 2021, the EPA approved this team as the independent consultant to undertake the EIA. This EIA has been prepared in compliance with the Guyana Environmental Protection Act (as amended in 2005), the Environmental Protection (Authorisation) Regulations (2000), the Environmental Impact Assessment Guidelines—Volume 1, Version 5 (EPA 2004), the Environmental Impact Assessment Guidelines—Volume 2, Version 4 (EPA/EAB 2000), good international oilfield practice, and EEPGL's corporate standards, and in accordance with the Consultants' standard practices.

1.2. PROJECT DEVELOPMENT HISTORY AND ANTICIPATED TIMELINE

Exploration results have led to an estimated recoverable resource in excess of 9 billion barrels (1.44 billion cubic meters) of oil-equivalent resource in the eastern half of the Stabroek Block offshore Guyana. Within this area and prior to the current proposed Project, three development projects have been proposed or permitted by EEGPL: Liza Phase 1, Liza Phase 2, and Payara. Yellowtail is the fourth development project in the eastern portion of the Stabroek Block.

EEPGL has drilled three exploration wells in the Yellowtail and Redtail fields within the Stabroek Block, as indicated in Table 1.2-1. After completion, each of these wells was plugged or will be plugged consistent with good international oilfield practice (World Bank 2015).

Table 1.2-1: EEPGL Stabroek Block Exploration Well Drilling History

Well Name	Year Drilled	Result
Yellowtail-1	2019	Successful
Yellowtail-2	2020	Successful
Redtail-1	2020	Successful

Based on the results of initial feasibility and conceptual design studies, Preliminary Front-End Engineering and Design for the Project is currently underway, to be followed by detailed engineering. In support of this activity, various baseline data collection studies have been undertaken at the Project site, as described elsewhere in this EIA. A preliminary schedule anticipates that FPSO and SURF fabrication and installation will begin in 2023 following the completion of engineering and will take approximately 3 years. Development well drilling may also occur during this period[3]. Production operations are expected to begin in 2026 and will continue for at least 20 years. The Project schedule and timeline will continue to be refined and are subject to change. Further detail on the Project timing and a detailed Project description are provided in Chapter 2, Description of the Project.

1.3. GOAL AND OBJECTIVES OF THE EIA

In accordance with the Final Terms and Scope for this EIA, issued by the EPA on 10 September 2021, the goal of the EIA is to provide the factual and technical basis required for the EPA to make an informed decision on EEPGL's Application for Environmental Authorisation.

To that end, this EIA has the following objectives:

- Describe the components and activities of the Project, including:
  - Development drilling, including well design and drill ships;
  - SURF;
  - FPSO, including topsides facilities and the vessel mooring system;
  - Installation, hookup, commissioning, and start-up of FPSO and SURF components;

[3] The Yellowtail drilling campaign could commence as early as the second quarter of 2022 for the purposes of accelerated subsurface data collection and optimal use of the Stabroek drill ship time. The potential scope for 2022 drilling could include top-hole sections of up to five wells, but likely no completions in the reservoir interval(s). In this case, wells would be temporarily plugged and re-entered for completion operations during the primary drilling campaign for the Yellowtail Project.

- Production operations, including offloading tankers;
- Onshore support, including shorebases;
- Marine and aviation support vessels and equipment; and
- End of Project operations (decommissioning).

- Describe the existing conditions within the Project Area of Influence (AOI). The evaluation of existing conditions in the Project AOI will leverage the scientific body of knowledge that has been acquired through various prior and ongoing studies and current operations' environmental monitoring.
- Identify and assess the potential direct, indirect, and cumulative environmental and socioeconomic impacts that could credibly result from the Project during the drilling, installation, commissioning, start-up, production, and decommissioning stages.
- Describe, to the extent possible, potential induced impacts associated with ancillary/support activities or facilities that may not be a component of the Project itself, but are associated with the Project.
- Describe a strategy to manage any potentially significant adverse impacts of the Project.
- Characterize potential positive benefits of the Project.
- Recommend monitoring to assess the effectiveness of the management strategy.

1.4. COMPONENTS OF THE EIA

This EIA has been prepared as one document presented in three volumes and organized as follows:

Volume I

- Environmental Impact Statement
- Chapter 1, Introduction and Project Scope
- Chapter 2, Description of the Project
- Chapter 3, Administrative Framework
- Chapter 4, Methodology for Preparing the Environmental Impact Assessment
- Chapter 5, Scope of the Environmental Impact Assessment
- Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources
- Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources
- Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
- Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events

- Chapter 10, Cumulative Impact Assessment
- Chapter 11, Environmental and Socioeconomic Management Plan Framework
- Chapter 12, Conclusions and Summary of Impacts
- Chapter 13, Recommendations
- Chapter 14, Project Team
- Chapter 15, References

Volume II

- Appendices

Volume III

- Environmental and Socioeconomic Management Plan (ESMP)
- Stakeholder Engagement Plan for Guyana Operations
- Preliminary End of Operations Decommissioning Plan
- Oil Spill Response Plan for Guyana Operations
- Comprehensive Waste Management Plan

This EIA has been prepared to provide the information required by the Guyana Environmental Protection Act (as amended in 2005) and as further described in the Guyana Environmental Impact Assessment Guidelines. The Environmental Impact Assessment Guidelines Volume 1—Rules and Procedures for Conducting and Reviewing EIAs, Version 5 (EPA 2004) includes an EIA Review Checklist. Provided below in Table 1.4-1 is an EIA “roadmap” that shows where in the submittal the checklist items can be found.

Table 1.4-1: EIA Review Checklist Roadmap

EIA Review Checklist Items	Corresponding EIA Reference
1. Adherence to the Terms of Reference (ToR) *Adherence to the ToR must be verified simply by checking that all items and information requested in the ToR have been presented, regardless of the content or quality of such information.*	• Adherence to the approved Terms and Scope (equivalent to the ToR as specified in the EIA Guidelines) issued by EPA on 10 September 2021
2. Multidisciplinary Team *The accuracy of the EIA depends on the qualifications of the multidisciplinary team not only regarding the EIA process and methods but also regarding their knowledge of the several stages of the specific type of project. Therefore, individual CVs should be submitted as part of the EIA Annexes. Signatures of each member of the team must be affixed.*	• Chapter 14, Project Team, lists core team members, Appendix A provides core team signatures, and Appendix B includes core team curricula vitae.
3. Inter-disciplinary Achievement *An EIA must present information regarding the interactions and integration between the physical, biological and socio-economic aspects of the environment in that particular area of the study.*	• Chapter 6 assesses impacts on physical resources • Chapter 7 assesses impacts on biological resources • Chapter 8 assesses impacts on socioeconomic resources[4]
4. Executive Summary *The Executive Summary, also referred to as the non-technical summary, should provide a brief description of the project and information regarding the potential impacts of the project, arranged in order of significance, along with the proposed mitigation/compensatory measures for each impact. The summary should end with the consultants' recommendations.*	• Executive Summary included in Environmental Impact Statement
5. Project Description *The process of environmental impact assessment depends on the full understanding of the project proposal and accurate identification of the project actions. If actions are unclear, sufficiently detailed impacts are not likely to be identified with the accuracy and specificity needed to enable the development of appropriate mitigation measures.*	
5.01 Is the project proposal fully understood?	• Chapter 2, Description of the Project
5.02 Are all phases identified (e.g. planning, construction, operation and decommissioning)?	• Section 2.5, Drilling and Well Design • Section 2.8, Installation, Hook-up, and Commissioning

[4] Findings in the one section that are pertinent to resources in another section (e.g., changes in physical habitat conditions that result in potential impacts to biological resources, changes in biological resources that are socioeconomically important, etc.) are integrated into the discussion of potential impacts to the other section.

EIA Review Checklist Items	Corresponding EIA Reference
	• Section 2.9, Start-up • Section 2.10, Additional Aspects of Production Operations, • Section 2.12, End of Yellowtail Operations (Decommissioning)
5.03 Is the geographical area for each phase identified?	• Section 2.1, Project Area (all stages occur within this same area)
5.04 Are the land use requirements for each phase identified?	• Section 2.11, Onshore, Marine, and Aviation Support (only onshore supply and support activities have any land use requirements)
5.05 Is there an inventory of the nature and quantity of materials used in the production process?	• Section 2.13, Materials, Emissions, Discharges, and Wastes
5.06 Are there inventories of the type and quantity of products, by-products and effluents expected to be produced by the project?	• Section 2.13, Materials, Emissions, Discharges, and Wastes
5.07 Is there an inventory of the type and quantity of residues?	• Section 2.13, Materials, Emissions, Discharges, and Wastes
5.08 Are the levels of emissions expected detailed with respect to *- Noise?* *- Vibration?* *- Light?* *- Heat?* *- Radiation?* *- Gases?* *- Liquids? Are the types and levels of any other emissions included?*	• Noise impacts: Section 6.2.3, Impact Assessment—Underwater Sound; Section 7.5.3, Impact Assessment—Marine Mammals; Section 7.7.3, Impact Assessment—Marine Turtles; Section 7.8.3, Impact Assessment—Marine Fish • Thermal and liquid discharges: Section 6.4.3, Impact Assessment—Marine Water Quality • Radiation: Section 2.13.5, Radiation Emission Sources • Air (gaseous) emissions: Section 6.1.3, Impact Assessment—Air Quality, Climate, and Climate Change
5.09 Is information on employment provided?	• Section 2.3, Project Workforce
6. Identification and Description of Alternatives *The assessment of sound alternatives is necessary to validate the EIA process. Therefore reasonable alternatives have to be fully and comprehensively considered. As a minimum, one of the following alternatives must be considered: location, project layout, technology, scheduling, project scale.*	• Section 2.18, Alternatives
6.01 Did the developer consider alternatives?	• Section 2.18, Alternatives
6.02 Was the "no-project" scenario considered?	• Section 2.18.4, No Action Alternative
6.03 Were the environmental factors adequately presented for each alternative?	• Section 2.18, Alternatives
6.04 Is the final choice adequate?	• Section 2.18, Alternatives • Chapter 12, Conclusions and Summary of Impacts

EIA Review Checklist Items	Corresponding EIA Reference
7. Definition and Justification of Physical Boundaries (Direct and Indirect Area of Influence) *Inconsistency in identifying the correct areas of influence will inevitably lead to inconsistency in the baseline data and the impact analysis. The indirect area of influence is the area likely to be affected by indirect, secondary and/or long term impacts.*	• Section 5.1, The Area of Influence
8. Analysis of the Legal Aspects Involved *The analysis of the legal framework involves more than a list of legal Acts. It involves assessing the consequences for the project of enforcing all the environmental legislation and regulations regarding the proposed site and sectoral requirements related to the proposed activity.*	• Chapter 3, Administrative Framework • Additionally, resource-specific administrative framework discussions are provided in each resource-specific section in Chapters 6, 7, and 8
9. Identification of Other Existing Planned Activities or Projects in the Area of Influence *This information is of utmost importance to ensure that land-use and other types of conflicts do not arise later during the project implementation.*	• Chapter 10, Cumulative Impact Assessment
9.01 Has the compatibility between the proposal and the identified existing activities been analysed?	• Section 10.4, Other Projects and External Drivers
9.02 Are the activities compatible?	• Section 10.4, Other Projects and External Drivers
9.03 Does the inventory of existing activities match what is observed?	• Section 10.4, Other Projects and External Drivers
10. Adequacy and Completeness of Relevant Baseline Data *Baseline data must be specific and relevant to the area of influence. General and superficial information does not allow for the use of adequate impact prediction techniques.*	• Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
10.01 Is the information presented specific and relevant?	• Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
10.02 Were difficulties in attaining information (if any) documented?	• Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources

EIA Review Checklist Items	Corresponding EIA Reference
	• Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
10.03 Have the impact indicators identified been adequately covered (see Section 13)	• Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
11. Appropriateness of EA Methods *The use of appropriate EA methods is necessary to ensure reliability of the results of the EIA study. Each type of EA method has different strengths and vulnerabilities regarding its appropriateness to perform each step of the EIA study. Some EA methods are unable to provide the means of identification of cause-effect relationships; others do not enable the identification of indirect, secondary and/or long-term impacts. Scientific and technical accuracy of the EIA methods used must therefore be evaluated to ensure the reliability of the conclusions drawn from the impact assessment.*	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment • Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
12.1. Physical Impacts *- Have all the identified impacts on air, water, soil, noise, landscape and natural resources been checked against the relevant impacts defined in the ToR?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?*	• Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources
12.2. Biological Impacts *- Have all the identified impacts on flora, fauna, rare / endangered species, sensitive ecosystems, species habitats and ecological balance been checked against the relevant impacts in the ToR.* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?*	• Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources

EIA Review Checklist Items	Corresponding EIA Reference
- Have the magnitudes been estimated? *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?*	
12.3. Social and Health Impacts *- Have all the identified impacts on the social and health context been checked against the relevant impacts defined in the ToR?* *- Are impacts identified with respect to human health, demographic and household characteristics, employment opportunities, size and distinguishing characteristics of resident population, the provision of social services and infrastructure?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?* *- To what extent does the project protect/improve human health?* *- To what extent does the project protect/improve human living conditions?*	• Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
12.4. Cultural, Historical and/or Archeological Impacts *- Have all the identified impacts related to cultural, historical and/or archeological sites and heritage been checked against the relevant impacts defined in the ToR?* *- Are impacts identified with respect to cultural heritage?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?*	• Section 8.7, Cultural Heritage

EIA Review Checklist Items	Corresponding EIA Reference
12.5. Economic Impacts *- Have all the identified impacts on the economy (local, regional, national) been checked against the relevant impacts defined in the ToR?* *- Are impacts identified with respect to economic assets and activities?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?* *- Are impacts identified with respect to income generation for the community and at the National Level?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?*	• Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
12.6. Other impacts *- Have all other impacts been checked against the relevant impacts defined in the ToR?* *- Are impacts identified with respect to _____?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Has the social distribution of the impacts been identified?* *- Have cause/effect relations been properly identified?*	• Other potentially impacted resources not specifically listed above have been included, such as marine geology and sediments (Section 6.3), marine use and transportation (Section 8.4), Indigenous Peoples (Section 8.10).

EIA Review Checklist Items	Corresponding EIA Reference
13. Cumulative Impacts *There may be cases where an activity/project will contribute to a cumulative impact on the environment although individually it may not have a significant environmental impact. This may be as a result of the presence of similar activities within the vicinity of the project.*	• Chapter 10, Cumulative Impact Assessment
13.01 Have cumulative impacts been adequately identified and characterized?	• Chapter 10, Cumulative Impact Assessment
13.02 Have the magnitudes been estimated?	• Section 10.6, Assessment of Cumulative Impacts on VECs (Valued Environmental and Social Components)
13.03 Have the impacts been assigned a significance?	• Section 10.6, Assessment of Cumulative Impacts on VECs
13.04 Has the social distribution of the impacts been identified?	• Section 10.6, Assessment of Cumulative Impacts on VECs
13.05 Have cause/effect relations been properly identified?	• Section 10.6, Assessment of Cumulative Impacts on VECs
14. Impact Indicators *Impact indicators are the parameters used to estimate the magnitude of the impacts.*	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment
14.01 Were the impact indicators used adequate for all the impacts identified?	• Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
15. Prediction Techniques *Impact prediction techniques are necessary to enable the estimation of the magnitude of the impacts. Without the use of adequate impact prediction techniques, accurate impact analysis is not possible.*	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment
15.01 Have the impact prediction techniques used been described? Are they adequate?	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment • Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources

EIA Review Checklist Items	Corresponding EIA Reference
15.02 Are they adequate?	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment • Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
16. Magnitude of Impacts *Magnitude is the estimate of the absolute measure/value/dimension of the difference between the environmental situation of a given parameter before and after the project is implemented. In the majority of cases – physical, biological and economic impacts – it must be expressed in* ***quantitative*** *values. The estimation of the magnitude of each relevant impact is one of the most important steps in impact analysis. It ensures the accuracy of the EIA and allows for the identification of appropriate and cost-effective mitigation measures. Have the magnitude of all the relevant impacts been adequately estimated (refer to impact indicators – Section 14)?*	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment • Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
17.0 Importance/Significance of Impacts *Usual methods involve objective criteria regarding the ecological and social relevance of the project*	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment
17.01 Is the relative importance/significance of each impact with regard to the environmental factor affected, and with regard to the other impacts given?	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment
17.02 Is the significance based on objective criteria in order to minimize subjectivity of judgments?	• Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
18 Social Distribution of Impacts *Identifies which social groups will be affected by the positive and the negative impacts. These groups are often not the same. The balance between positive and negative impacts cannot be done without the correct identification of the social distribution of the impacts, because it would not have scientific and technical relevance.*	• Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources

EIA Review Checklist Items	Corresponding EIA Reference
19 Stakeholder Participation	
19.01 Are the results of stakeholder participation, such as the results of interviews, hearings etc. clearly documented?	• Section 4.7, Stakeholder Engagement
19.02 Have questionnaires used been included?	• Numerous Key Informant Interviews, informal meetings, and capacity-building workshops, as well as five scoping consultation meetings were held.
19.03 Are the extent and method of stakeholder participation adequate?	• Section 4.7, Stakeholder Engagement
19.04 Are the conclusions drawn valid, based on available data?	• Section 4.7, Stakeholder Engagement
20 Analysis and Selection of Best Alternative *Selection must be based on criteria derived from the impact assessment, and appropriate analysis and decision-making methods must be used.*	• Section 2.18, Alternatives • Chapter 12, Conclusions and Summary of Impacts
21 Environmental Management Plan (EMP) *An EMP is sometimes called an Impact Management Plan. It is a necessary step to ensure that the developer is effectively committed to the implementation of the mitigation measures. It is also a useful corporate management tool. Does the EMP, as a minimum, present* *- The set of mitigation, remedial or compensatory measures?* *- A detailed description of each one, with indication and criteria for their effectiveness?* *- Detailed budgets for each one?* *- Timetables for implementation?* *- Assignment of responsibilities, including an Environmental Manager?* *- The Environmental Policy*	• Chapter 11, Environmental and Socioeconomic Management Plan Framework • ESMP
22 Monitoring *Monitoring is a necessary step to ensure cost-effectiveness of the EMP. It is usually addressed under the EMP (see Section 20) Does the monitoring plan, as a minimum, address* *- What is going to be monitored (impact indicators)?* *- Where will samples be taken?* *- How the samples will be analysed (method/technique)?* *- Criteria used to evaluate the results?* *- Financial and human resources required?*	• ESMP

EIA Review Checklist Items	Corresponding EIA Reference
23 Implementation Plan for the Mitigation Measures and the Environmental Management Plan *Implementation mechanisms must be in place to ensure effective implementation of the mitigation measures and all other recommendations that might arise from the EIA study. It usually involves the assignment of a person responsible for environmental management and an approved timetable for implementation of measures.*	• Chapter 11, Environmental and Socioeconomic Management Plan Framework • ESMP

2. DESCRIPTION OF THE PROJECT

Based on exploration and assessment activities, EEPGL has identified the presence of multiple reservoirs of crude oil with an estimated recoverable resource in excess of 9 billion barrels[1] (1.43 billion cubic meters [m^3]) of oil-equivalent resource in the eastern half of the Stabroek Block. The Project described herein represents EEGPL's fourth development in the eastern half of the Stabroek Block, in the Yellowtail and Redtail fields and potentially proximal resources.

The Project will consist of drilling approximately 45 to 67 development wells (including production, water injection, and gas re-injection wells); installation and operation of Subsea, Umbilicals, Risers, and Flowlines (SURF) equipment; installation and operation of a Floating Production, Storage, and Offloading (FPSO) vessel in the eastern half of the Stabroek Block (Figure 2-1); and ultimately, Project decommissioning. Onshore logistical support facilities and marine/aviation services will be used to support each stage of the Project.

This chapter discusses the following information related to the Project:

- Project area;
- Project schedule;
- Project workforce;
- Overview of development concept;
- Drilling and well design;
- SURF;
- FPSO vessel, including topsides facilities and the vessel mooring system;
- Installation, hook-up, commissioning, and start-up activities;
- Production operations, including offloading by third-party owned/operated conventional tankers;
- Onshore, marine, and aviation support;
- End of operations (decommissioning);
- Materials, emissions, discharges, and wastes;
- Embedded controls;[2]
- Worker health and safety;
- Project benefits; and
- Project alternatives.

[1] A barrel of oil-equivalent is a unit of energy based on the approximate energy released from combusting one barrel (42 U.S. gallons or approximately 159 liters) of crude oil.

[2] Embedded controls are physical or procedural controls that are planned as part of the Project design (i.e., not added solely based on a mitigation need identified by the impact significance assignment process). These are considered from the very start of the impact assessment process as part of the Project, and are factored in to the pre-mitigation impact significance ratings.

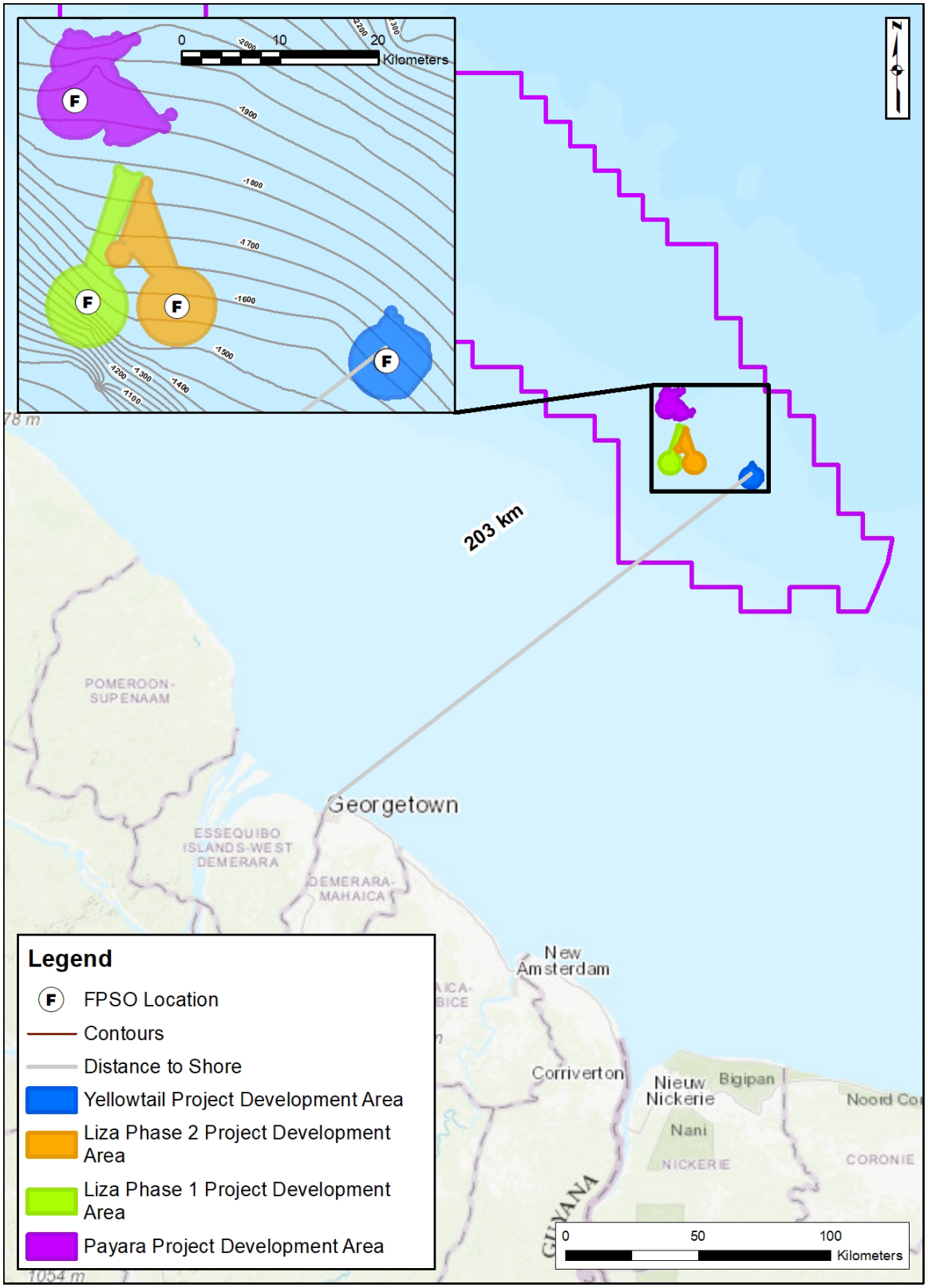


Figure 2-1: Location of the Yellowtail Project Development Area within Stabroek Block

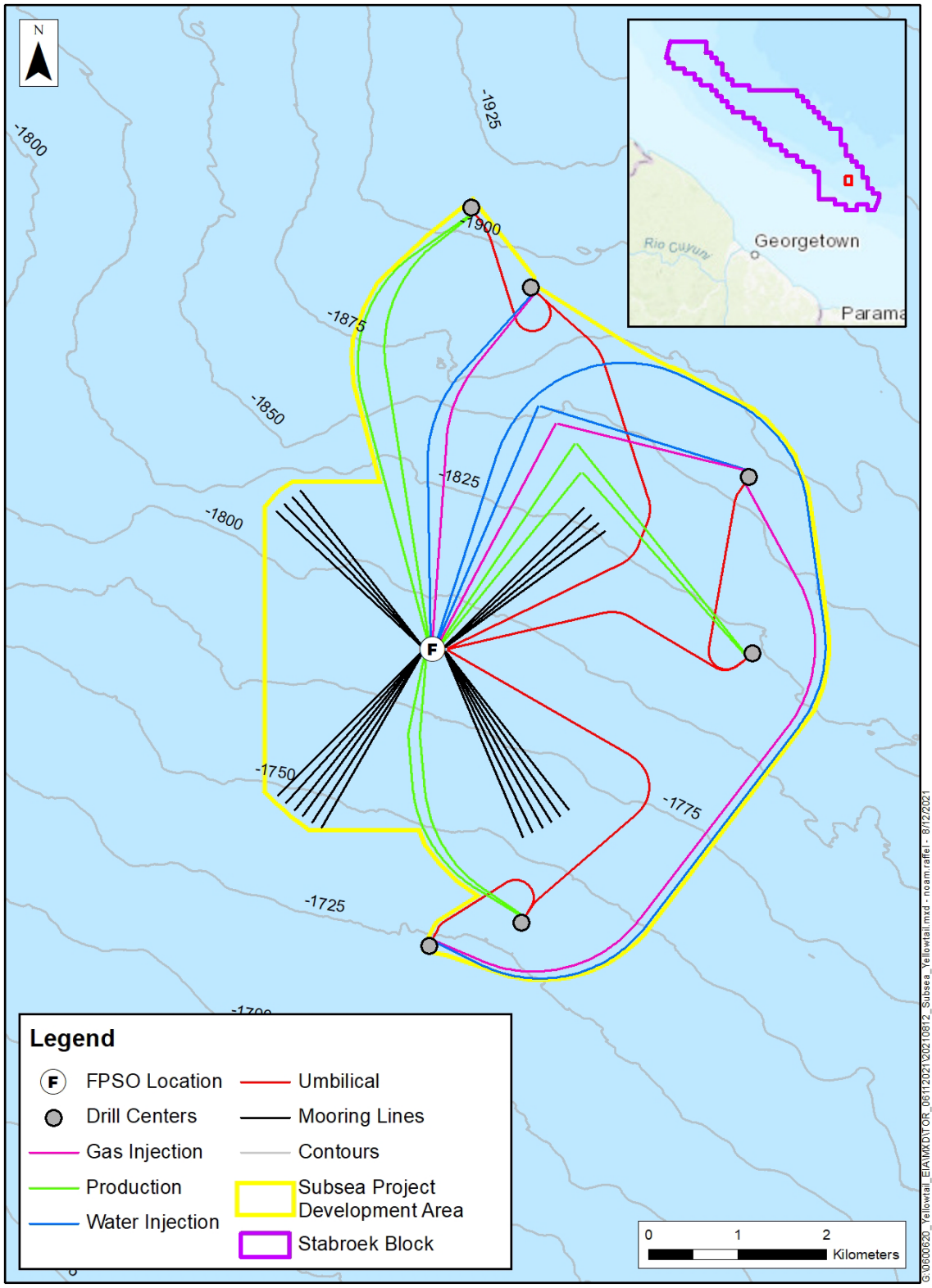
2.1. PROJECT AREA

The Stabroek Block, which covers an area of approximately 26,800 square kilometers (6,622,398 acres), is oriented roughly parallel to the Guyana coastline, extending across the entire width (northwest to southeast) of Guyana territorial waters. Components of the Project will be located on the seafloor, in the water column, and at the ocean surface. The combined extent of the area affected by both surface and subsea components and activities is referred to as the Project Development Area (PDA) and covers an area of approximately 4,998 hectares (12,350 acres). Figure 2-1 illustrates the location of the PDA within the Stabroek Block; the PDA is located approximately 203 kilometers (126 miles) northeast of the coastline of Georgetown, Guyana. Figures 2.1-1 and 2.1-2 illustrate the preliminary conceptual layout of the FPSO, the SURF equipment, and the drill centers within the PDA.

The exact locations of the Yellowtail development wells have not been finalized; however, the wells will be drilled from six drill centers[3]. During drilling and installation of the FPSO/SURF facilities, work may be performed in a subsea area within the PDA that could potentially cover an estimated 3,534 hectares (8,733 acres). This area is referred to as the Subsea PDA. Much of this subsea area will not involve physical disturbance of the seafloor except where the SURF equipment and the FPSO mooring system are sited, as shown on Figure 2.1-1.

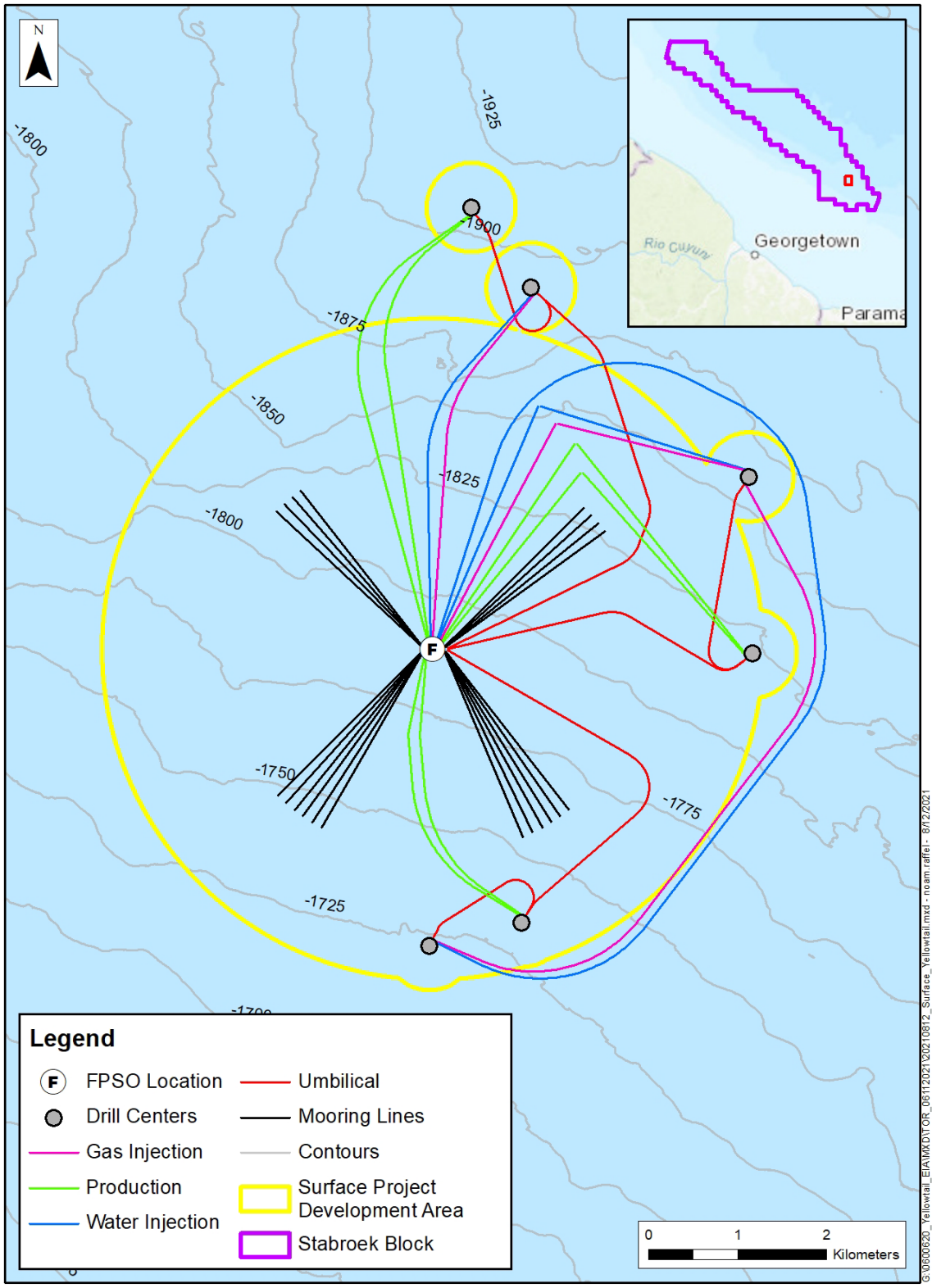
During the production operations stage, work performed on the surface of the ocean could potentially occur within an estimated 4,576 hectares (11,308 acres). This area is referred to as the Surface PDA. As further described in subsequent sections and shown on Figure 2.1-2, this area of the ocean surface may have operational constraints that would restrict unauthorized vessels from entering defined marine safety exclusion zones during drilling, installation, and production operations. While Figure 2.1-2 shows six marine safety exclusion zones around the drilling manifold locations, drilling will not occur at all locations simultaneously. The marine safety exclusion zones for the large installation vessels that will conduct FPSO and SURF facility installation are not denoted on Figure 2.1-2; however, the size of these marine safety exclusion zones will be similar to those used for the drill ships.

[3] For the Project, *a drill center* is defined as a group of wells (including production, water injection, and/or gas re-injection wells) clustered around one or more manifolds. Each of the six drill centers incorporates separate manifolds that are separated by several kilometers and are designed for production or injection. For example, Drill Center 4 will be separated into production (DC4-P) and injection (DC4-I) components.



Note: Locations on figure subject to change

Figure 2.1-1: Yellowtail Subsea Project Development Area



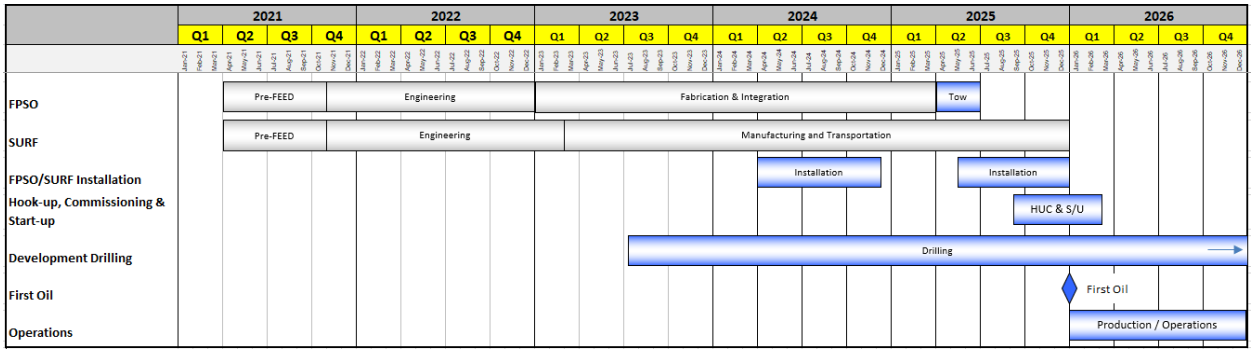
Note: Locations on figure subject to change

Figure 2.1-2: Yellowtail Surface Project Development Area

2.2. PROJECT SCHEDULE

The Project life cycle will include engineering, development drilling, installation, hook-up, commissioning, start-up, production operations, and decommissioning. Production operations will follow start-up and will be the longest stage of the Project.

Figure 2.2-1 provides a preliminary schedule for the major Project components and activities up to the start of production operations. As depicted on Figure 2.2-1, initial oil production is planned for early 2026. To support this timing, development-well drilling is planned to start in mid-2023. Pending receipt of authorization, the drilling campaign could commence as early as 2Q2022 for the purposes of accelerated subsurface data collection and optimal use of drill ship time. The potential scope for 2022 drilling could include top-hole sections of up to five wells, but likely no completions in the reservoir interval(s). In this case, wells would be temporarily plugged and reentered for completion operations during the primary drilling campaign for the Project. Drilling could extend as late as 2032 depending on the total number of wells drilled. Installation of subsea components is planned to begin in 2024; the FPSO installation, commissioning, and start-up are planned to occur in 2025. Production will continue for at least 20 years. These milestones are still being refined and are subject to change. This schedule provides for simultaneous development drilling and FPSO/SURF production operations after start-up.



HUC = hook-up and commissioning; SU = start-up
This reflects the current preliminary Project schedule and remains subject to adjustment. Some activities (e.g., development drilling, HUC, and SU) may begin early than indicated pending receipt of environmental authorization or continue longer due to unforeseen delays.

Figure 2.2-1: Preliminary Project Schedule

2.3. PROJECT WORKFORCE

Preliminary workforce estimates are provided in Table 2.3-1. These estimates may be further refined following selection and contracting for the drill ship(s), FPSO, SURF installation, support vessels, and shorebase support facilities. The current plan is to conduct primary support activities from shorebases in Guyana, with the potential for some activities to be conducted from shorebases in Trinidad and Tobago.

Table 2.3-1: Preliminary Workforce Estimates

Project Stage	Estimated Workforce
Development well drilling	Approximately 540 personnel at peak (Assuming up to three full-time drill ships used concurrently and dependent upon final drill ship and support vessel selection.)
FPSO and SURF mobilization, installation, hook-up, commissioning, and start-up	Approximately 600 personnel at peak (Dependent upon final construction/installation and support vessel selection.)
Production operations, including FPSO and conventional export tankers	Approximately 100 to 140 personnel at peak (an additional 25 to 30 personnel will be on board each export tanker)
Decommissioning	Approximately 60 personnel at peak

As noted in Table 2.3-1, there will be a demand of up to 540 persons (at peak, assuming up to three drill ships operating concurrently) required to drill and complete the Yellowtail development wells. The majority of these personnel will work in the offshore environment on drill ships. Most of these roles will require prior offshore oil and gas industry experience and specialized expertise. However, the prior development of the Liza Phase 1, Liza Phase 2, and Payara projects will allow for continuous capacity building of the workforce, as additional personnel are upskilled and given greater responsibilities. This will create opportunities to increase the pool of semi-skilled and skilled workers that can support the Project. There will be a demand for approximately 600 workers required to mobilize, install, and hook up the Project FPSO and SURF equipment. The installation stage will provide only short-term opportunities for Guyanese workforce, as a majority of these personnel will work in the offshore environment and will require specific technical skills and experience.

During long-term production operations, the in-country, direct offshore workforce will peak at around 100 to 140 people during periods of higher maintenance activity and during offloading of an FPSO. During periods of regular operations, the workforce requirement on an FPSO is estimated to be on the order of 90 to 100 people. To provide long-term, sustainable opportunities for Guyanese workers, the Project has established specific targets for the Guyanese workforce on the FPSO during production operations. For the Yellowtail Project FPSO, EEPGL is targeting an initial local content of 25 percent, increasing to approximately 75 percent by the end of 8 years of operation.

EEPGL is working closely with its contractors and subcontractors in identifying additional suitable opportunities for Guyanese workforce development. Through demand categorization workshops administered by the Project, several workforce sectors can be accessed now or through additional capacity-building efforts. These include the following categories of labor:

- Shorebase semi-skilled and skilled labor;
- Supply vessel basic skilled labor;
- Office support—administration/logistics;
- Environmental support—Protected Species Observers;
- Drill ship semi-skilled labor;
- Supply vessel semi-skilled labor;
- Tubular running semi-skilled labor;
- Tertiary welding semi-skilled labor;
- Roustabouts / crane operators / marine deck crews; and
- Selected service company personnel and casing crews.

In-country labor recruitment for the installation activities will be driven by the demand of the Project for specific craft skills and required number of craft workers to maintain the Project schedule. EEPGL has encouraged its contractors and subcontractors to implement a transparent process to advertise job opportunities locally and receive applications from potential candidates. For example, advertisements for Operations and Maintenance are distributed throughout Guyana through the Regional Democratic Councils, which then share ads with Neighbourhood Democratic Councils, the National Toshaos Council, the Ministry of Indigenous Peoples, the Council of Technical and Vocational Education Training (TVET) (to all technical institutes and centers), and the Indigenous Peoples Association.

In addition to the offshore components, there will also be personnel providing shorebase and marine logistical support on shore (approximately 150 to 200 personnel), some of whom will be Project-dedicated while others will be shared resources. The onshore logistical support staff will ramp up gradually through the mobilization and installation stage until reaching a peak during the development drilling campaign and FPSO/SURF installation activities. Additional personnel will be used as Protected Species Observers onboard designated Project vessels.

As mentioned above, the majority of the workforce required offshore during all stages of work will be skilled labor. During the drilling and installation stages, the majority of the offshore workforce will be foreign workers, while the onshore workforce (shorebase, marine logistical support, and operations management) will be a mix between skilled and semi-skilled labor requiring both foreign and local workers. During the production stage, the workforce will evolve to comprise a majority of Guyanese personnel. It is further estimated that a large majority (more than 95 percent) of the offshore foreign labor during the drilling and installation stages will not require onshore housing, as they will use their companies' shared guest houses or will spend one to two nights in hotels while rotating in/out of country.

EEPGL is committed to supporting the economic and social development of the communities where it operates. In July 2017, EEPGL established the Centre for Local Business Development to assist small- and medium-sized Guyanese businesses building their capacity and improving

their competitiveness for the broader economy. In addition, EEPGL has been working closely with the TVET to identify training areas where development will not only fit into the emerging industry, but will also offer sustainable skills to young Guyanese. Following visits to Guyana's regional institutions and in-depth discussions to review the existing TVET Programs, EEPGL and the regional institutions have aligned in the selection of craft skill areas to develop diverse vocational programs, which will further develop competencies. Those craft skills are expected to produce an enhanced technical workforce with the ability to span different economic sectors.

EEPGL is also committed to exploring various training formats that may include, but are not limited to, on-the-job training, mentoring, classroom training, e-learning, and self-taught programs. In addition, contractors and subcontractors are evaluating other training options in collaboration with local institutions to build capacity of potential candidates prior to the start of the work. These institutions include:

- Existing vocational and technical education institutions and centers;
- Aeronautical Institute; and
- University of Guyana.

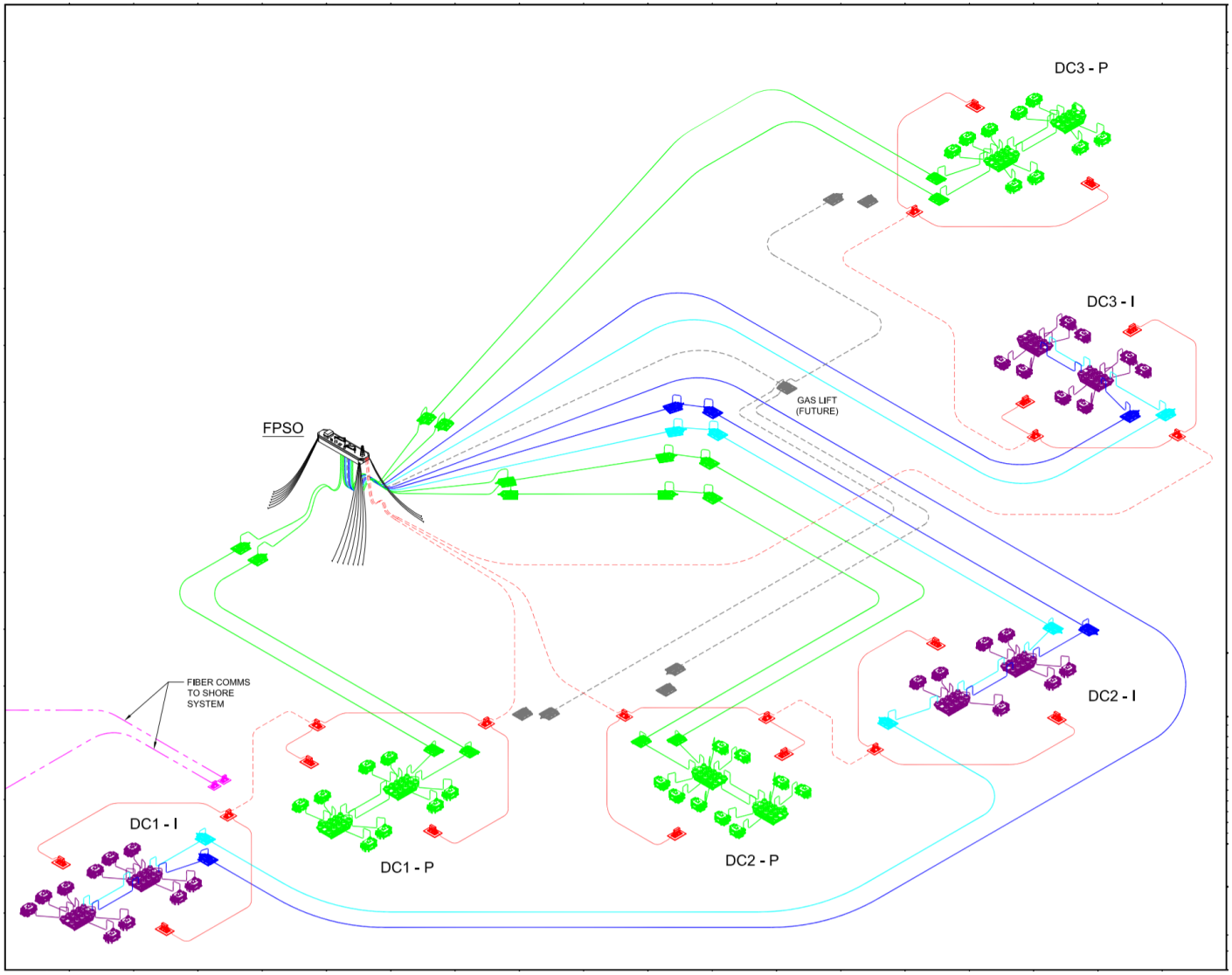
Through the Greater Guyana Initiative (funded by the Stabroek Block co-venturers), EEPGL has launched several programs with the Council for TVET, including Basic Industrial Safety Training as well as two pilot programs in Linden and New Amsterdam for electrical and welding. In addition, it has launched Zoom Rooms at the University of Guyana, allowing more than 600 students and instructors to interact. At the University of Guyana, a Professor of Practice Program[4] is also progressing.

2.4. OVERVIEW OF THE DEVELOPMENT CONCEPT

2.4.1. Development Concept

The Yellowtail and Redtail fields, and potentially proximal resources, will be developed as part of the Project, with approximately 45 to 67 development wells drilled from six drill centers, each with separate production, gas re-injection, and water injection manifolds. Figure 2.4-1 illustrates the preliminary field layout for the Project facilities, including representative development wells, SURF, and a spread-moored FPSO. The facility layout will continue to evolve during the design development process. The various components included on Figure 2.4-1 are further described below in the relevant drilling, SURF, and FPSO sections.

[4] As per the University of Guyana's "Approved Guidelines for the Appointment of Endowed Chairs, Professors of Practice and Distinguished Professorships," internationally, appointments to these positions and similarly titled positions such as "practice professors," "professors of the practice," and "professors of professional practice" have commonly been reserved for practitioners who are appointed because of skills and expertise acquired in nonacademic careers (University of Guyana 2019).



Green = production; light blue = gas injection; dark blue = water injection; red = umbilicals; gray = gas lift

Figure 2.4-1: Preliminary Yellowtail Field Layout

The development wells include production wells, water injection wells, and gas re-injection wells. A portion of the associated gas produced from the reservoir will be used onboard the FPSO as fuel gas and the remaining balance—excluding other *de minimis* sources not captured by the Vapor Recovery Unit (VRU)—will be re-injected back into the reservoir via the gas re-injection wells. Water injection and gas re-injection will be used as needed to maintain reservoir pressure for optimal production over the life cycle of the Project.

The Project will use a spread-moored FPSO (see Section 2.7, Floating Production, Storage, and Offloading Vessel). The FPSO will support the topsides facilities, process the produced fluids from the production wells, and store the processed crude oil until offloading. Offloading of the processed crude oil for export will occur directly to conventional tankers. Subsea production, gas re-injection, and water injection wells and manifolds will be linked directly to the FPSO via flowlines and risers (see Section 2.6, Subsea Umbilicals, Risers, and Flowlines).

2.4.2. Applicable Codes, Standards, and Management Systems

The various aspects of engineering design and operations will be carried out according to applicable Guyana statutory requirements, applicable international design codes and standards, applicable EEPGL and contractor design specifications, the EEPGL Operations Integrity Management System (OIMS), and EEPGL Safety, Security, Health, and Environment policies[5]. EEPGL and its contractors will have a structured management system to verify the ongoing application of all necessary codes, standards, procedures, and management systems. An overview of the EEPGL OIMS framework is included in Chapter 3, Administrative Framework.

2.5. DRILLING AND WELL DESIGN

2.5.1. Drilling Program

The Project will use several drill ships similar to that shown on Figure 2.5-1 to drill the development wells. The number of drill ships required will be determined during the design development process based primarily on the number of wells required for initial oil production. For the purposes of the EIA, up to three full-time drill ships working concurrently on Project development wells is the basis of analysis. Additional drill ships may be used to accelerate the drilling schedule, as allowed by simultaneous operations. Drilling operations may occur prior to, during, and after the installation of the FPSO and SURF components.

[5] The policies are part of the overall Standards of Business Conduct policy: http://corporate.exxonmobil.com/en/company/about-us/guiding-principles/standards-of-business-conduct.

Figure 2.5-1: Typical Drill Ship

The drill ship provides the operational base and power needed to conduct the drilling operation. During the drilling process, drill ships will require various tubulars[6], instruments, and devices (collectively referred to as the drill string) to conduct the well construction process, which consists of drilling the borehole, running and cementing casings using a sequential batch drilling program, and installing the completion and production tubing. The drill ship advances the drill string into the well and provides the torque to turn the bit in the borehole. All of the equipment used to assemble and manipulate the drill string, such as the travelling equipment and rotating system, will be housed on the drill ship.

[6] Tubulars include various types of piping, such as drill pipe, drill collars, casing, and production tubing.

The wellheads will be clustered around six drill centers rather than being distributed over the seabed above the producing reservoirs. This approach reduces the number of drilling locations, thereby reducing the seabed area potentially affected by drilling operations, including discharge of drill cuttings[7]. The planned development-drilling program and its cuttings management approach is consistent with good international oilfield practice (World Bank 2015), has previously been the basis for exploration wells in the Stabroek Block, and is also the basis for the development wells for the Liza Phase 1, Liza Phase 2, and Payara Development Projects.

2.5.2. Typical Well Design

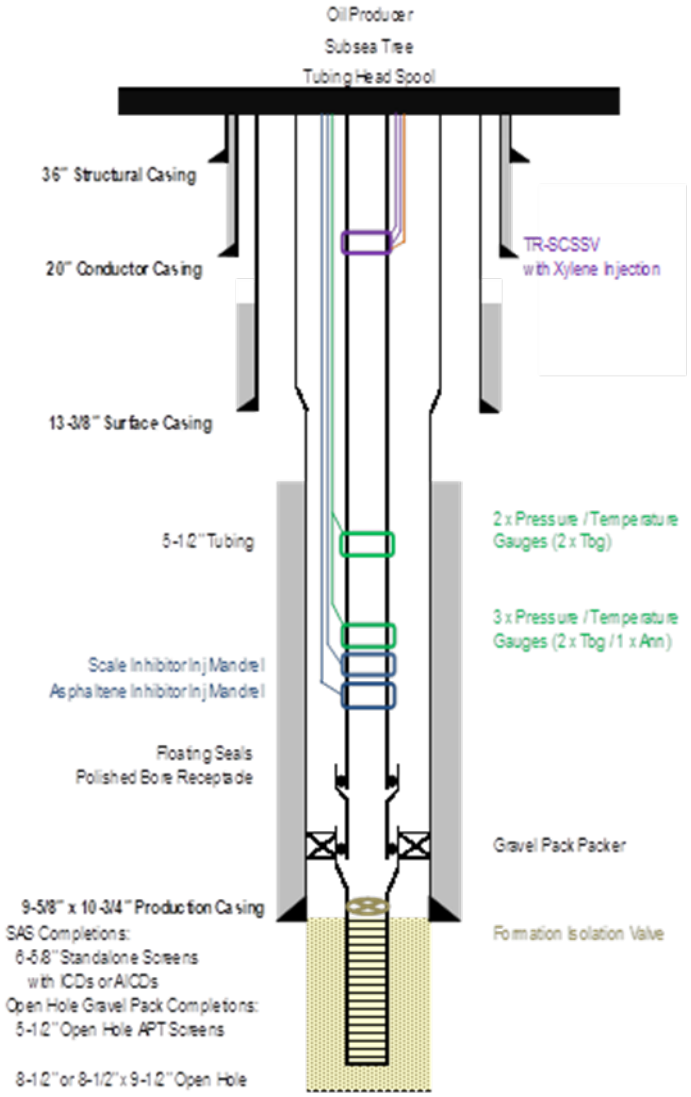
This section describes features of the development wells that will be installed for the Project. Exploration wells are structurally similar to development wells and are drilled using similar processes and equipment.

The drilling process uses drill bits of different sizes to drill a series of telescoping holes from the seabed to the planned well total depth. Drill pipe is continuously added to the top of the drill string from the drill ship as the drill string advances into the borehole. Once the borehole is started for a well, pipe (also known as casing) is inserted into the borehole and cemented in place to keep the well from collapsing and to seal the casing to the formation. Various-sized casings are progressively set as the well is drilled deeper. After each casing (for the conductor casing and deeper casings) is installed, pressure and integrity testing is performed according to good international oilfield practice (World Bank 2015).

Cements, produced in a combustion process using a specialized blend of limestone and clay, are used to support the casing and isolate formations. With increasing depth, temperature, and pressure, additives are required so that the cement slurry maintains its required properties. Additives can be subdivided into six functional groups: (1) density control additives, (2) setting time control additives, (3) lost circulation additives, (4) filtration control additives, (5) viscosity control additives, and (6) specialty additives.

A provisional well program and design for the Yellowtail development-drilling program, including preliminary casing types and sizes, setting depths, drilling fluid types, and discharge locations, is shown on Figure 2.5-2. Figure 2.5-3 shows the various components of a typical subsea drilling system.

[7] Drill cuttings are the broken bits of solid material produced as the drill bit advances through the borehole in the rock or soil.



SCSSV = surface-controlled subsurface safety valve

Figure 2.5-2: Provisional Casing Program for Development Drilling Program

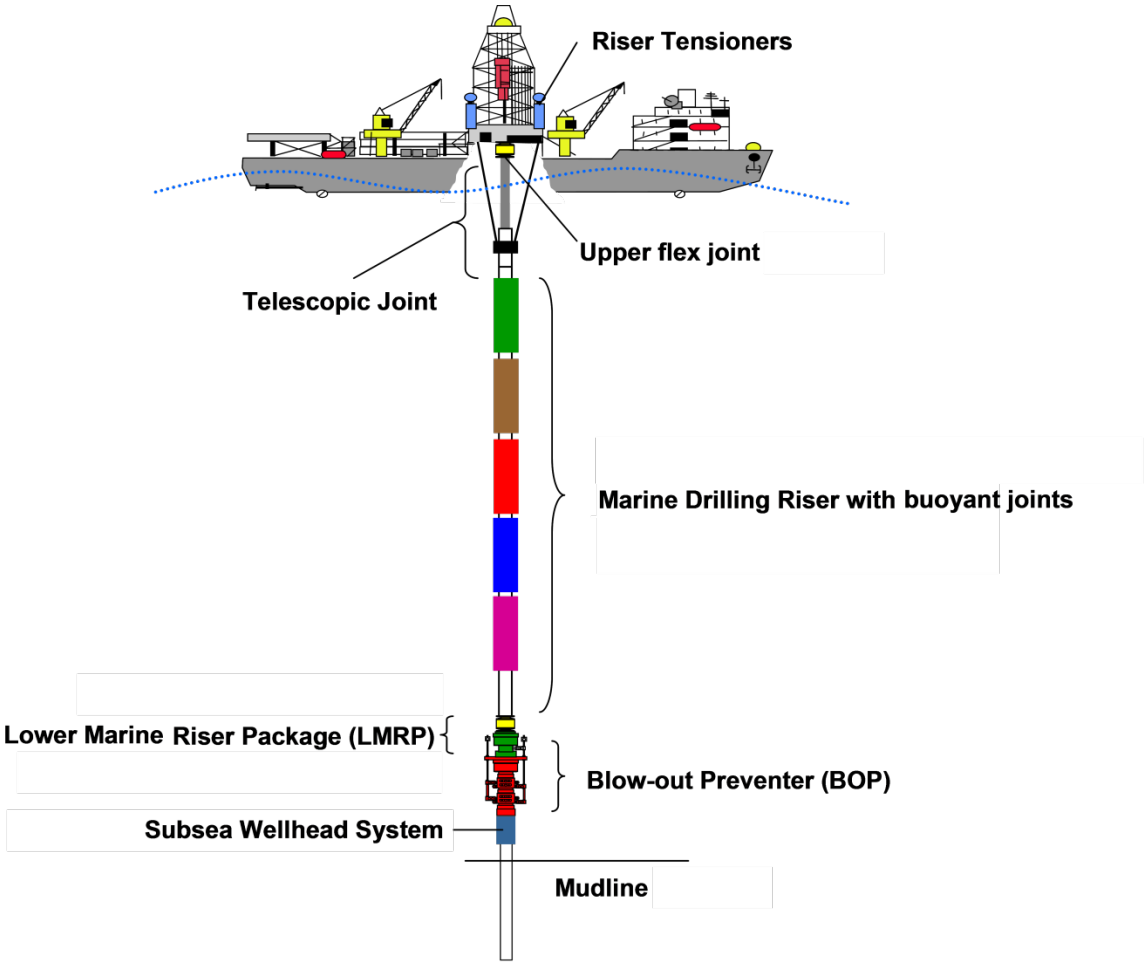


Figure 2.5-3: Typical Subsea Drilling System

2.5.3. Drilling Fluids and Handling System

Drilling fluids are circulated through the inside of the drill string to the bit. Drilling fluids are selected to be suitable for deepwater operations and the temperatures and pressures that will be encountered, to facilitate safety and integrity of the drilling operations, including well control and borehole stability. The primary function of the drilling fluid system is to remove cuttings and to control formation pressures. The choice of drilling fluids will be based on the challenges associated with drilling in deepwater environments, which differ from shallow water drilling in the following aspects:

- Colder temperature / higher seawater hydrostatic pressure at the mudline;
- More narrow window between pore pressure[8] and fracture gradient[9]; and
- Longer drilling risers requiring larger volumes of drilling fluid.

The drilling fluid is designed to have specific properties and is prepared by mixing solid additives and chemicals to specified concentrations. Three categories of drilling fluids will be used:

[8] Pressure of fluids within the pores of a reservoir
[9] Pressure required to induce fractures in rock at a given depth

seawater, water-based drilling fluids (WBDF), and non-aqueous drilling fluids (NADF)—the latter of which has a continuous phase that is an International Association of Oil and Gas Producers (IOGP) Group III low-toxicity non-aqueous base fluid (NABF) with low to negligible aromatic content. [10] WBDF will be used when drilling the upper sections of the well. Based on wellbore stability analysis and experience gained from exploration drilling, NADF will be required to maintain borehole stability while drilling all well sections below the conductor casing.

WBDF returns and drill cuttings are discharged at the seabed. This is consistent with good international oilfield practice used globally to drill the top-hole sections of development and exploration wells (World Bank 2015). WBDF contains no hydrocarbons; accordingly, no treatment of WBDF-based cuttings is required. Figure 2.5-4 is a schematic depicting the discharge of WBDF returns and drill cuttings at the seabed.

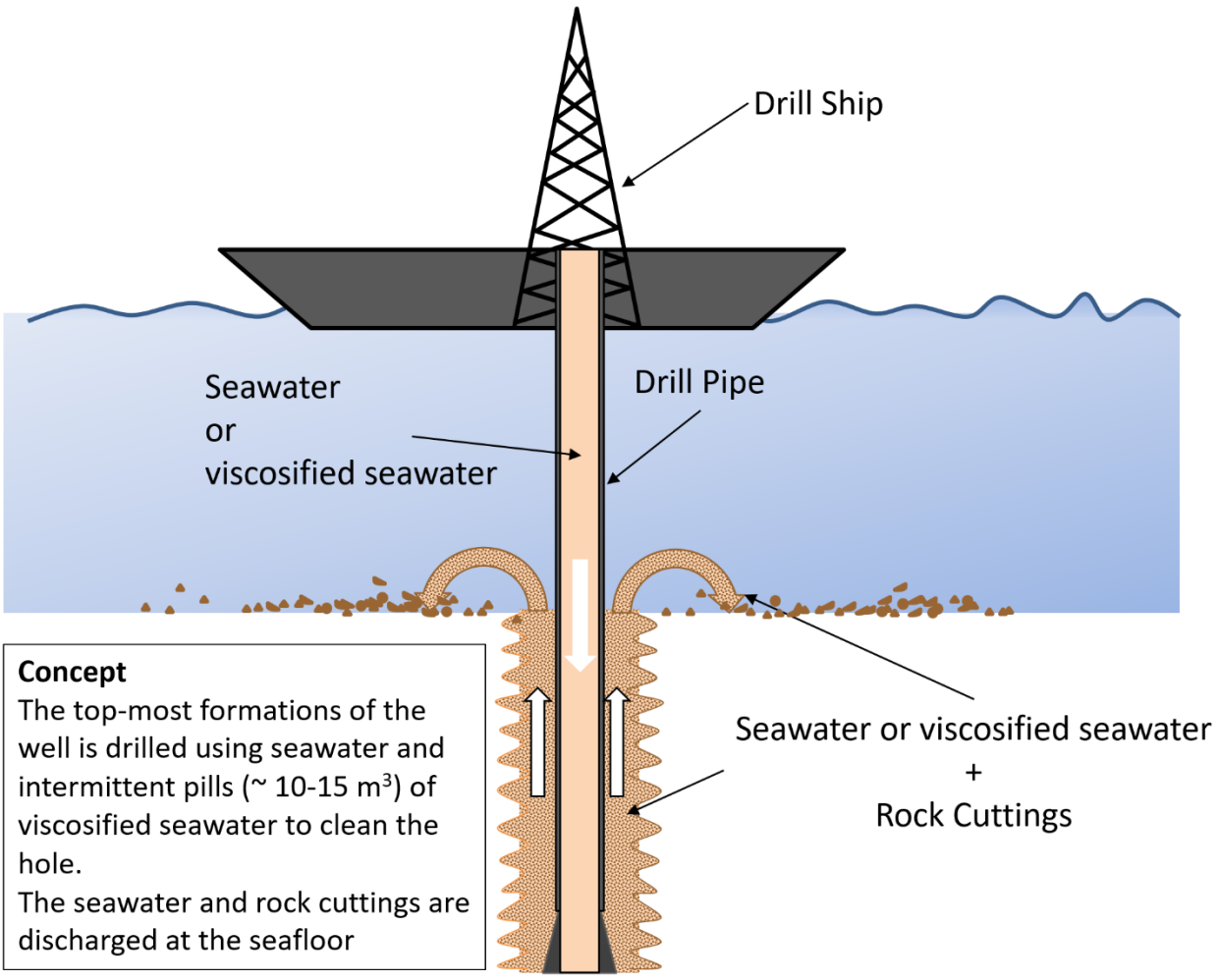


Figure 2.5-4: Discharge of WBDF Returns and Drilling Cuttings at Seabed

[10] NADFs contain more than 30 percent NABF as a continuous phase (typically 50 to 80 percent by volume). The remainder of NADF consists of brine, barite, and other materials such as gels and emulsifiers (IOGP 2015).

WBDF contains the following commonly used types of products: salt water, polymers, and stabilizers. More specifically, they include the following:

- Sodium chloride brine—this is salt water made from table salt; it is largely the same salt as seawater, but a little more concentrated.
- Xanthan gum—this is a polysaccharide with many industrial uses, including as a common food additive. It is an effective thickening agent and stabilizer to prevent ingredients from separating. It can be produced from simple sugars using a fermentation process and derives its name from the species of bacteria used (*Xanthomonas campestris*). Xanthan gum can be found as an ingredient in many foods such as ketchup, yogurt, and salad dressing, among others. It is not harmful to humans or the marine environment.
- Caustic soda—this is used in low concentrations to stabilize the fluid to a pH of 7.5–9.0.
- Bactericide—this is used in a very low concentration (5 gallons per 1,000 barrels [18.9 liters per 160 m^3]); it is similar to caustic soda in that it helps as a stabilizer for xanthan gum.
- Barite—this is a naturally occurring mineral (barium sulfate, an inert solid).

This is a standard formulation for WBDF and is also used for drilling top-hole sections in the Gulf of Mexico. All of these products disperse quickly in the seawater and degrade readily with the exception of barite—an inert mineral used to increase the density of the fluids critical for safety.

A properly formulated NADF does not promote the formation of ice-like crystals, as can occur with the use of WBDFs, and the lubricity of the NADF allows longer and higher deviation wells to access hydrocarbon reserves from fewer drill centers. A typical NADF does not invade into the formation and also maintains safety through borehole stability during the drilling of well sections below the conductor casing.

NADF-based drilling fluids recovered from the well will be treated to remove solids and/or gas entrained in the fluid during the drilling phase. Solids control and cuttings drying equipment will be installed on the drill ships for this purpose—to process and reduce the percentage of NABF retained on cuttings. The solids control system will separate drill cuttings and particles of solids from the circulating drilling fluid system. Once the marine riser is installed, the flow of drilling fluid returning from the well will be directed to the solids control system. The removal of solids from the returning flow enables reuse of the base fluid. Thus, the solid removal system performs an important role in the drilling operation by maintaining optimal drilling fluid properties, reducing the volume of base fluid required, and reducing fluid properties of drilling waste generated. Using this method, the NABF retained on cuttings can be reduced to less than 6.9 percent by weight, which is good international oilfield practice for offshore discharge (World Bank 2015). NADF-based cuttings will be discharged to the sea from the drill ships after treatment, in accordance with good international oilfield practice. The use of this equipment on other similar projects has significantly reduced the percentage of NABF retained on cuttings.

Figure 2.5-5 provides a diagram of a generic cuttings drying system. Drill cuttings and fluids are described and listed in Tables 2.13-2, 2.13-6, and 2.13-7. Additionally, Appendix C, Water

Quality Modeling Report (Volume II of the regulatory submittal), includes additional details on the modeling results and dispositional study for such discharges.

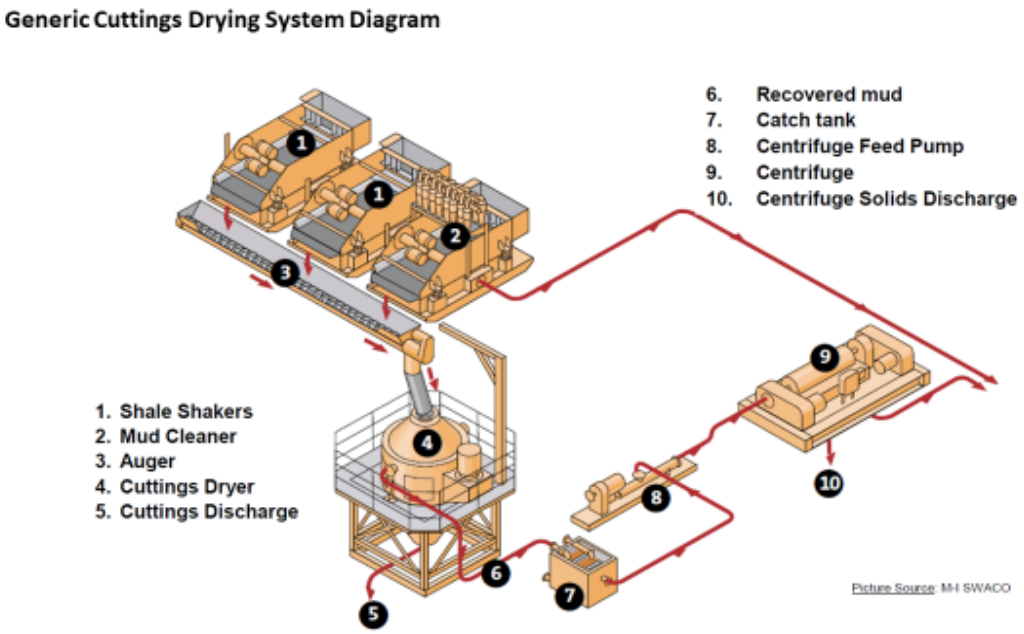


Figure 2.5-5: Generic Cuttings Drying System

2.5.4. Well Control

ExxonMobil's well-control philosophy (and those of its affiliate EEPGL's) is focused on blowout prevention using safety and risk management systems, management of change procedures, good international oilfield practice, and trained experienced personnel. ExxonMobil's OIMS emphasizes attention to safety, well control, and environmental protection. This includes proper preparation for wells (well design, well-control equipment inspection, and testing), detecting an influx early, closing-in the well efficiently in such a situation (for which personnel training and proficiency drills are conducted), and circulating-out kicks with weighted drilling fluid in a controlled manner.

The following key aspects of well control are common to all ExxonMobil drilling projects, and will be implemented during the Project drilling campaign:

- Designing wells and drilling procedures based on site-specific data and integrated pore pressure prediction;
- Planning fluid densities to control reservoir pressure;
- Installing blowout preventer (BOP) equipment as a secondary well-control mechanism and frequently inspecting and testing the BOP and control system;
- Specialized training, equipment, and procedures that meet or exceed regulatory requirements; and

- Installing redundant well-flow monitoring devices and implementing strict well-monitoring practices to maximize the likelihood of detecting and shutting in a hydrocarbon influx prior to surface release.

With respect to training and proficiency drills, EEPGL conducts well-control training and drills to build drilling crew proficiency, specifically as it relates to detecting and efficiently responding to a potential influx. Drilling crew leadership positions (e.g., toolpusher, driller, assistant driller) complete accredited classroom-based well-control training commensurate with industry standards and drilling contractor internal requirements. Well-control drills are held on each drill ship with each drilling crew to reinforce training and build operational proficiency. With respect to EEPGL operations in Guyana, well-control drills include, but are not necessarily limited to, pit drills, trip drills, power choke drills, and emergency disconnect / hang-off drills. These drills are performed at regular intervals over the course of operations. Pit drills are conducted to reduce the time required for the drilling crew to detect and respond to a potential influx while drilling. Trip drills are conducted to reduce the time required for the drilling crew to detect and respond to a potential influx while running or retrieving pipe from the well. Power choke drills are conducted to provide drilling crew members practice in operating the rig chokes, as would be used during an influx circulation. Emergency disconnect / hang-off drills are conducted to provide the drillers practice in simulating the rig-specific emergency disconnect sequence procedure, as would be implemented during an emergency disconnect event.

Should an influx occur, standard well-control procedures will be employed; these could include closing-in the well efficiently and circulating-out kicks with kill-weight fluids[11] in a controlled manner.

Blowout prevention while drilling and operating wells relies on a number of interrelated processes and procedures. Drilling will be performed using an overbalanced drilling fluid weight[12] to control the well. As discussed above, drilling fluids will provide primary well control during execution operations, as they are designed to exert enough hydrostatic pressure on the wellbore to exceed pore pressures, thereby preventing undesired fluid flow into the wellbore. Insufficient drilling fluid weight could lead to an underbalanced condition, and may, in turn, result in an influx of formation fluids. Excessive drilling fluid weight may result in lost circulation, which could in turn lead to a drop in fluid level and an underbalanced condition. A range of drilling fluid weights will be used as the well is drilled to provide the proper well control for the formation conditions encountered. Managed pressure drilling may be used in wells with narrow margins and to improve wellbore stability. During managed pressure drilling operations, an underbalanced drilling fluid may be used while drilling in combination with a surface back-pressure to provide primary well control.

[11] A “kick” is an influx from the drilled formation/rock. The drilling fluid weight (density) is increased (the resulting fluid referred to as “kill-weight fluid”) to balance the pore pressure in the formation/rock.
[12] In overbalanced drilling, the pressure exerted by the drilling fluid column exceeds formation pressure, preventing formation fluids from entering the well.

The BOP will provide secondary well control during drilling operations once the riser has been installed. Constant monitoring of the total fluid circulating volume and other drilling parameters (as described below) will facilitate an early detection of an instance where an influx of formation fluid into the well occurs. If an influx of formation fluid occurs, secondary well-control methods will be applied. The drill pipe will be shut-in by a downhole check valve near the bit and a surface-mounted safety valve. The well annulus will be shut-in using the BOP. In the event primary well control is lost, actuation of the BOP will contain the influx of formation fluid and then allow safe circulation of the influx out of the wellbore. Specifically, the BOP's main functions include:

- Closing around the drill string, casing, or liner and allowing circulation;
- Closing and sealing open holes and allowing volumetric well-control operations;
- Stripping the drill pipe using the annular preventers;
- Hanging-off drill pipe and controlling the wellbore; and
- Shearing cable or drill pipe.

BOPs are hydraulically activated closing devices. They are installed in series, and BOPs installed on a well are often referred to collectively as the "BOP stack." BOPs consist of both ram- and annular-type preventers.

The BOP stack provides capability to shut-in the well. With the well shut-in and with controlled back-pressure, kill-weight drilling fluid can be circulated through the well via the drill stem, annulus, and choke and/or kill lines to achieve the necessary bottom-hole pressure and stop the flow of fluids from the reservoir into the well. Figure 2.5-6 shows the components of a BOP system configuration.

Figure 2.5-6: Typical Blowout Preventer System

2.5.5. Well Cleanup and Ancillary Processes

2.5.5.1. Well Cleanup

Development wells will be drilled, completed, and tied back to the FPSO. Well cleanup fluids are fluids (wellstream, completion fluids, etc.) that initially come from the reservoir; these fluids are directed back to the FPSO topsides facilities for processing:

- Non-aqueous fluids will follow the oil stream and will be blended into the oil shipment.
- Water soluble components will be treated via the produced water treatment system prior to discharge overboard in alignment with produced water performance criteria (does not exceed oil-in-water content of 29 milligrams per liter [mg/L] monthly average or 42 mg/L daily maximum).
- Facilities will be provided for online removal of fluids and solids (commonly called *de-sanding facilities*) from the test separator.

2.5.5.2. Vertical Seismic Profiling

Vertical Seismic Profile (VSP) data may be collected to improve velocity modeling and reduce uncertainty in reservoir mapping. VSP surveys can be used to correlate the surface-seismic data to the information on the physical properties and characteristics of the hydrocarbons gained from drilling the well. VSP data, along with check shots and well logs, provide further time/depth information from which to improve knowledge and understanding of the structure and stratigraphy of a reservoir.

A VSP survey requires a sound source (commonly compressed air) and a receiver. Data are acquired by the receiver, which is installed within the wellbore. The source may be located above the wellhead or may be located farther away or “walked away” using a boat. The final scope of such a survey and specific geophysical tools to be used is still under review.

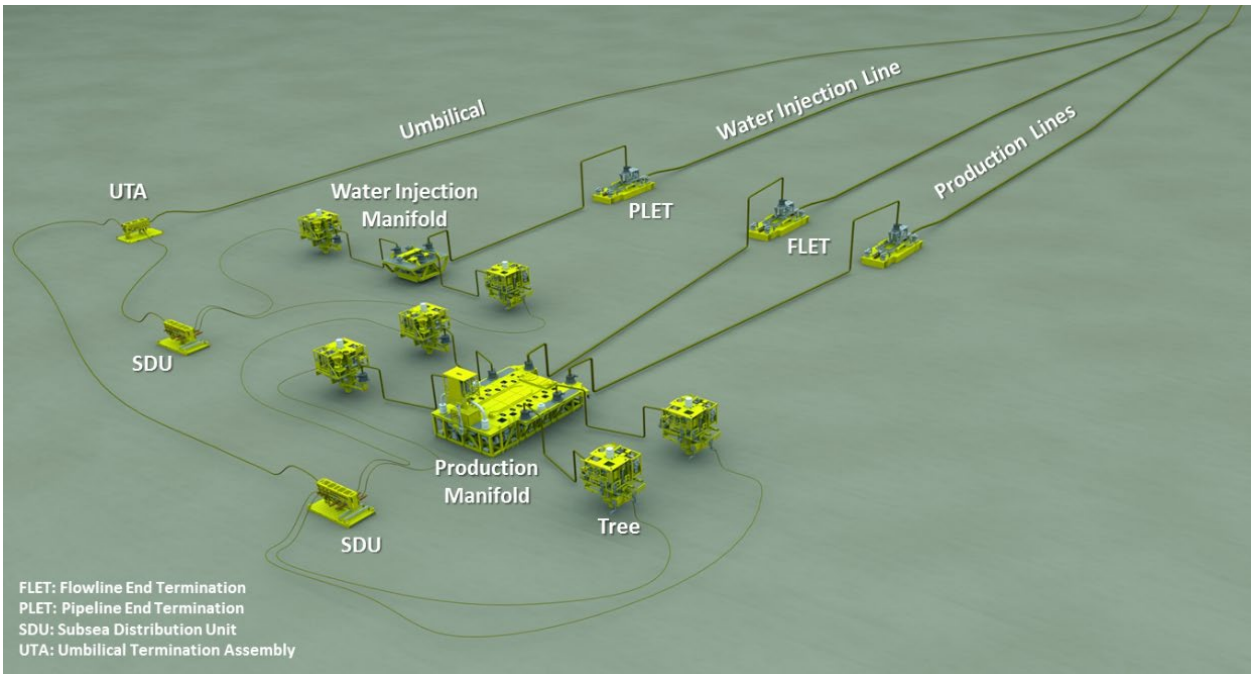
2.6. SUBSEA, UMBILICALS, RISERS, AND FLOWLINES

The SURF facilities for the Project will include subsea production, gas re-injection, and water injection wells clustered around subsea manifolds. The development wells will be drilled from six drill centers. This approach of clustering the wells around drill centers reduces the required number of manifolds, flowlines, and umbilicals[13], as well as the size of equipment and marine vessels needed for installation. The risers and umbilicals will connect the infrastructure on the seafloor to the FPSO. The manifolds will connect the individual development wells to the rest of the subsea system. The subsea system will be monitored and controlled from the FPSO using a control system connected to the FPSO through umbilicals that also supply power, hydraulic fluid, and chemicals to the subsea manifolds and wellhead trees[14]. The hydraulic fluid for operating the subsea control system will be a low-toxicity, water-soluble hydraulic fluid. The

[13] A cable and/or hose that provides the electrical, hydraulic, chemical, and communications connections needed to provide power and control between the FPSO and subsea equipment

[14] Assembly of valves, spools, pressure gauges, and chokes fitted to the wellhead of a completed well to control production

SURF system will be designed to withstand the full shut-in pressure from the production wells, and the gas re-injection / water injection components will be designed to withstand the highest required injection pressures. Overpressure protection will be provided on the FPSO, in accordance with good international oilfield practice, to protect the subsea systems (World Bank 2015). Figure 2.6-1 shows an illustration of a representative SURF system similar to what is currently being designed for the Project.



Note: Schematic is not representative of number of drill centers or wells and subsea equipment required

Figure 2.6-1: Representative SURF System

The production drill centers also will be connected to the FPSO with round-trip “piggable” production flowlines. A “pig” is a specially designed device that is placed in the flowline at a “launcher” and pushed by pressure until it reaches a receiving trap or “catcher.” Pigging is performed to aid in the maintenance, operations, cleaning, and/or inspection of flowlines. Figure 2.6-2 shows an example of a pig with wire cleaning brushes.

Figure 2.6-2: Example of Wire Brush Cleaning Pig

2.6.1. Well Flow Connections

Well flow connections between the subsea wells and the FPSO include several components. Each subsea development well is capped by a wellhead tree, which includes a choke valve to control production or water injection / gas re-injection. For a given set of wells tied to the same manifold, each wellhead tree is connected by jumpers to the well manifold, which is connected by a flowline jumper to a flowline end termination (FLET) located at the drill center end of the flowline.

A typical configuration of subsea wells, flowlines, and manifolds at a drill center is shown on Figure 2.6-3.

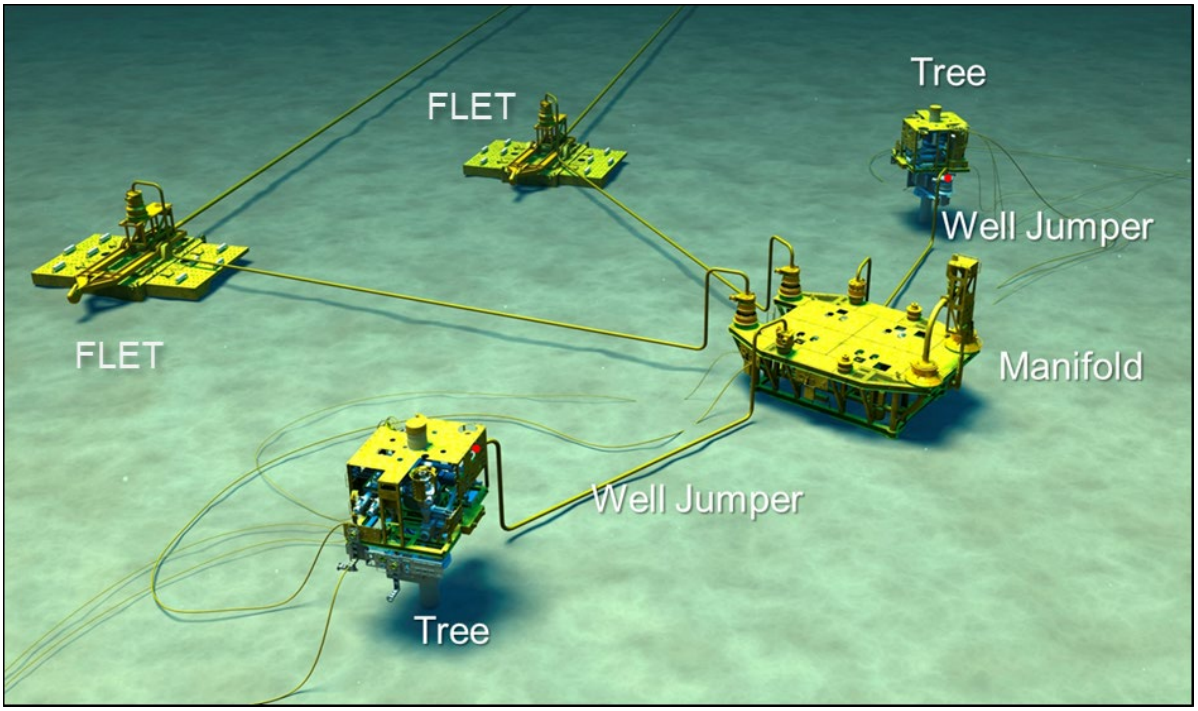


Figure 2.6-3: Typical Subsea Wellhead Tree, Jumper, and Manifold

From the drill center, the rigid flowline travels on the seabed to the vicinity of the FPSO. At the FPSO end of the flowline, the flowline transitions to a flexible riser, which carries the fluids between the seafloor and the FPSO at the surface.

The risers transition from the seabed to the FPSO in a “lazy wave” configuration as shown on Figure 2.6-4.

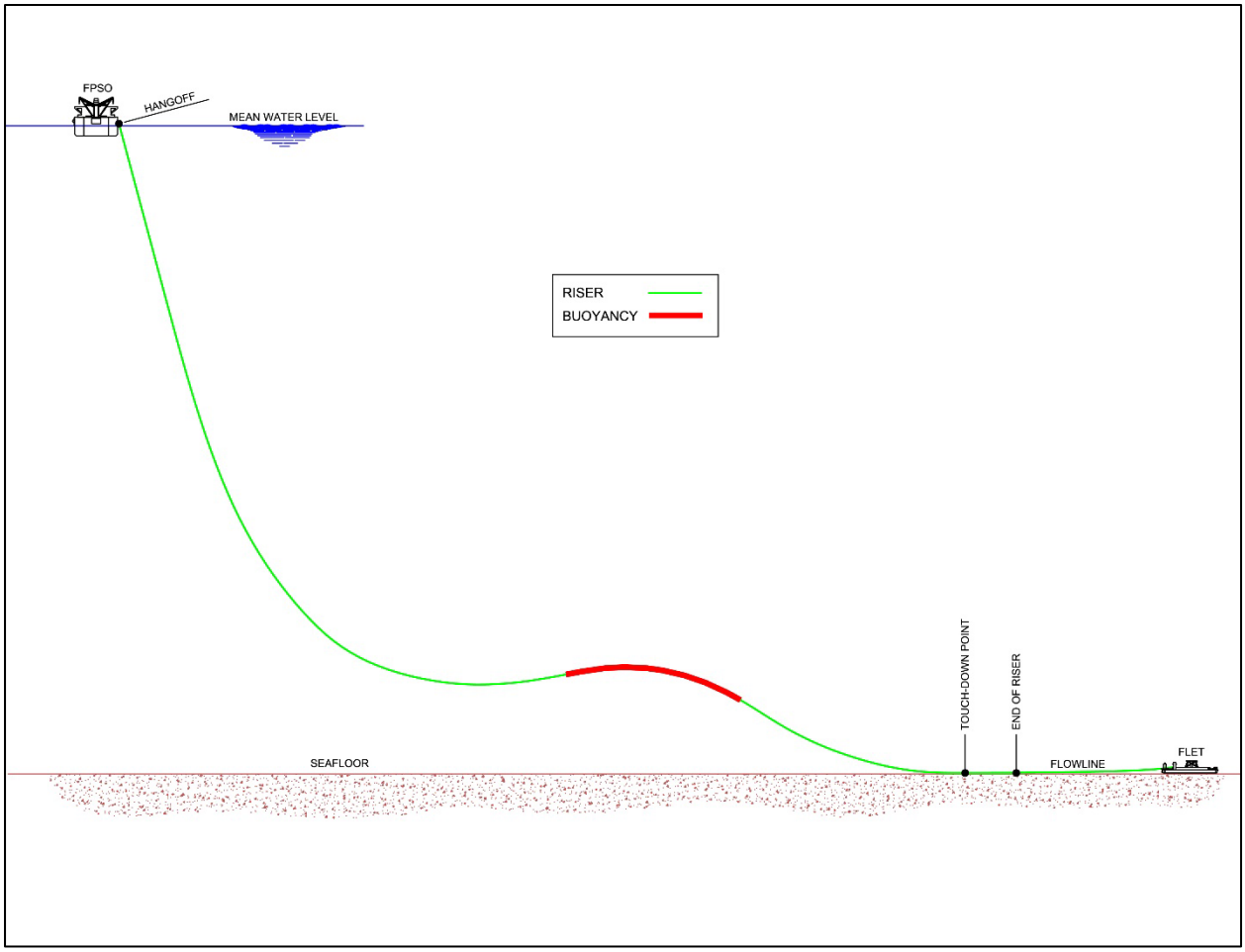


Figure 2.6-4: Representative Lazy Wave Riser

2.6.2. FPSO Subsea System Control

The FPSO will provide power, utilities, cabling, and tubing/piping tie-ins to equipment installed on its topsides to control the subsea equipment (see Figure 2.6-5). The FPSO will be configured with backup power so operations can continue in the event primary power is lost.

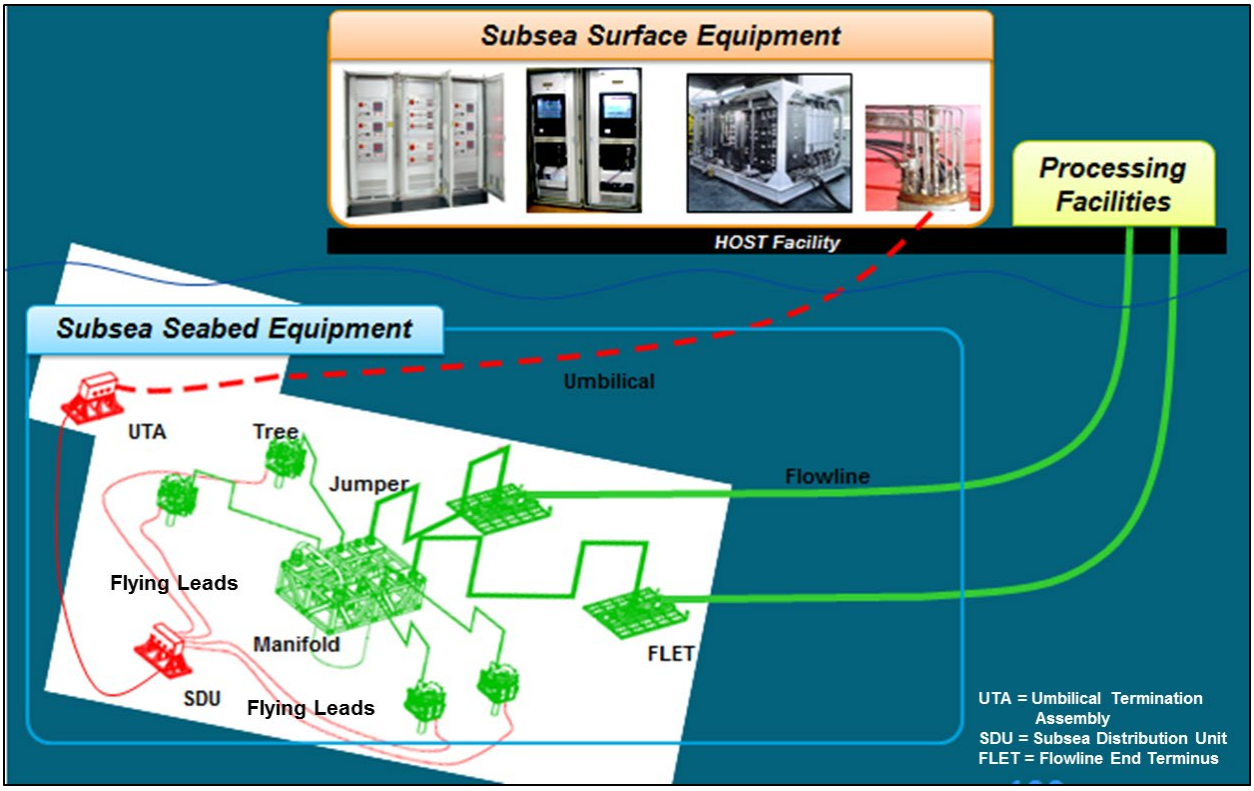


Figure 2.6-5: Representative Subsea Control System

The subsea wells and manifolds will be monitored and controlled from the FPSO. Each tree will have a Subsea Control Module mounted on it that controls and monitors the tree functions (e.g., choke-valve position) and associated manifold functions. Subsea controls will accommodate typical monitoring requirements such as pressure and temperature measurement.

The control systems at each drill center will be supplied from the Process Control System (PCS) on the FPSO by an umbilical. The umbilical will supply control fluid to operate all hydraulically operated valves, provide chemicals as required to facilitate flow to the FPSO, and provide low-voltage power and communication to operate and monitor the SURF facilities. The umbilical will terminate subsea to an Umbilical Termination Assembly. Hydraulic and electrical leads ("flying leads") will be used to connect the Umbilical Termination Assembly to the Subsea Distribution Unit (SDU), and the SDU to the well-mounted subsea control modules.

2.6.3. Risers, Flowlines, Umbilicals, and Manifolds

2.6.3.1. Risers and Flowlines

The Project will incorporate production, water injection, and gas re-injection flowlines and risers, as shown on Figure 2.4-1. Flowline and umbilical lengths will range from approximately 1 to 8 kilometers (approximately 0.6 to 5 miles), excluding risers, in water depths of approximately 1,700 to 1,900 meters (5,577 to 6,234 feet). The current design lengths are based on

preliminary shallow hazard surveys and current field layout and may be adjusted slightly during detailed design.

2.6.3.2. Umbilicals

Umbilicals will be designed as an integrated bundle of tubes and cables to serve multiple functions (see Figure 2.6-6). Three dynamic umbilicals connected to the FPSO will service the entire Yellowtail field. The remaining drill center components, composed of the subsea trees, manifolds, flying leads, and jumpers, will be connected via in-field / static umbilicals.

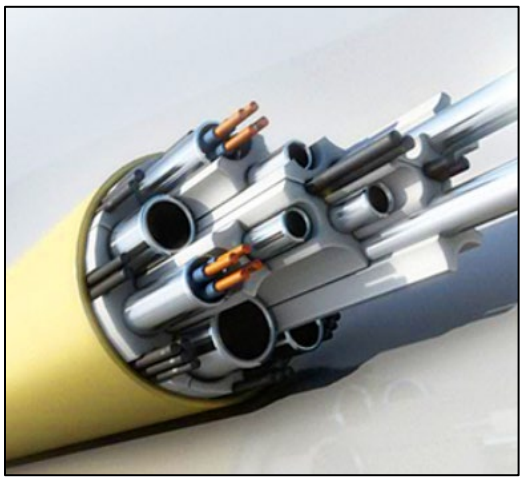


Figure 2.6-6: Representative Dynamic Umbilical

2.6.3.3. Manifolds

Manifolds are gathering points or central connections made up of valves, hubs, piping, sensors, and control modules. Manifolds (see Figure 2.6-7) include a protective structural framework that rests on a foundation on the seabed where multiple trees, jumpers, and flowlines gather to consolidate flows before they are transported either to the surface as part of production or back downhole as part of injection into the reservoir.

Figure 2.6-7: Representative Subsea Manifold

2.6.3.4. Gas-Lift System

The FPSO riser support system will be designed for gas-lift[15] capability. The gas-lift system is not required for initial start-up and may be installed at some future time during the Yellowtail service life based on the production characteristics of the field. This system will include gas-lift flowlines with connections to the production FLETs.

2.7. FLOATING PRODUCTION, STORAGE, AND OFFLOADING VESSEL

2.7.1. General Description

The Project FPSO will use a spread-moored configuration to maintain station continuously for at least 20 years. The FPSO will be designed to accommodate an annual average capacity of 300,000 barrels per day (48,000 cubic meters per day [m^3/d]) for total liquids production (250,000 barrels per day [40,000 m^3/d] and 225,000 barrels per day [36,000 m^3/d] of oil and water production, respectively), 300,000 barrels per day [48,000 m^3/d] for water injection, and 450 million standard cubic feet per day (12.7 million standard cubic meters per day [$MMsm^3/d$]) for gas processing. The FPSO will be capable of storing 2 million barrels (320,000 m^3) of

[15] Gas lift is a technique by which production can be increased by injecting high-pressure gas into fluids that have entered the production tubing from the formation.

stabilized crude oil. The FPSO will be able to offload approximately 1 million barrels (160,000 m^3) to a tanker in a period of approximately 24 hours.

The FPSO will also have the capability to process, dehydrate, compress, and re-inject the gas produced from the reservoir. The FPSO will be configured to treat seawater used for facility cooling purposes and for injection into the reservoir, and to process produced water for discharge overboard. Living quarters and associated utilities will be provided to support the operations on the FPSO. The FPSO topsides equipment and design will have a design life of at least 20 years.

Table 2.7-1 provides an estimate of the design rates for the FPSO facility.

Table 2.7-1: FPSO Key Design Rates

Service	Annual Average [a]
Oil Production, BPD (m^3/d)	250,000 (40,000) [b]
Water Production, BPD (m^3/d)	225,000 (36,000)
Total Liquids Production, BPD (m^3/d)	300,000 (48,000)
Gas Production, MMscfd ($MMsm^3$/d)	450 (12.7)
Gas Injection, MMscfd ($MMsm^3$/d) [c]	415 (11.8)
Water Injection, BPD (m^3/d)	300,000 (48,000)

BPD = barrels per day; MMscfd = million standard cubic feet per day
[a] Design rates presented are design maximum annual averages and peak rates may be higher during the lifetime of the Project, depending on multiple factors (e.g., reservoir pressure, number of wells, equipment reliability, etc.).
[b] Currently, the FPSO basic design has an upper production limit of 263,000 BPD (42,080 m^3) peak oil production rate. If during the detailed design stage or during production operations an opportunity to expand the upper production limit arises, the Project will document the evaluation and justification and an updated upper production limit will be available.
[c] Assumes 35 MMscfd (0.99 $MMsm^3$/d) of associated gas will be used as fuel gas for the FPSO. This estimate may be adjusted during detailed design as vendor documentation is received, and may vary over the Project life cycle. Fuel gas is used primarily for power generation and to run mechanically driven compressors; as the power and compression demand will fluctuate over time, so will the fuel gas demand.

Key FPSO design features include the following:

- The FPSO will be designed to remain moored for at least 20 years without dry-docking and will include facilities to support in-water hull/structural surveys and repair and maintenance.
- The FPSO will be designed to operate in extreme (100-year return period) environmental conditions (associated wind, waves, and current).
- The FPSO will be designed to re-inject associated gas under routine conditions—except that which will be used as fuel gas, flare pilot gas and background flare gas (e.g., purge, compressor seals) for FPSO operations and other *de minimis* sources not captured by the VRU—back into the reservoir except during times of injection / compression system unavailability, which will require temporary, non-routine flaring during maintenance/repair. Gas compression equipment, including sparing design elements, is discussed in Section 2.7.4.2, Gas Processing.

A picture of a typical FPSO is provided on Figure 2.7-1.

Figure 2.7-1: Typical FPSO

2.7.2. FPSO Topsides—Processing Facilities

The FPSO's topsides design uses an interconnected module concept where process equipment is packaged in modules. The design concept maximizes pre-commissioning and functional testing of the modules prior to arrival offshore Guyana. The FPSO will arrive for installation, hook-up, and commissioning in the Stabroek Block fully fabricated and preassembled.

The following are the principal functions of the topsides process facilities:

- To receive, separate, and process the reservoir fluids to provide:
  - Crude oil for offloading onto conventional tankers;
  - Treated produced water of sufficient quality for environmentally acceptable discharge to the sea; and
  - treated associated gas to meet requirements for: (1) fuel gas to be used at the FPSO for power generation and (2) re-injection into the reservoir; and
- To treat seawater to provide a suitable supply of water for injection into the reservoir.

2.7.3. FPSO Topsides—Accommodations Facilities

The FPSO will provide support systems for the safe accommodation of up to 160 personnel involved in the operation of the production facilities and, on occasion, personnel involved with the drilling program.

Temporary accommodations may also be used during key activities including hook-up, commissioning, and maintenance operations to increase accommodations capacity up to 180 personnel. In some cases, accommodations vessels may be used in the PDA to support needs for additional bunk space offshore.

The FPSO accommodations block will be located at the stern of the vessel, isolated from processing equipment, and positioned in proximity to the fully enclosed lifeboats. It will be outfitted, decorated, and furnished according to current shipbuilding standards and of a modern European style. The cabins will be a mix of one-, two-, and four-person person cabins. Some cabins will have an associated dayroom/office, some will be superintendent-type[16] cabins, and some will be regular sleeping cabins. Noise levels within the cabins are designed for less than 45 decibels (A-weighted). The cabins in the accommodation block are designed to accommodate a total complement of up to 160 personnel on board.

The accommodations block will also be outfitted with recreational spaces available to all personnel onboard, including a quiet lounge and library, recreation lounge, gymnasium, and smoking room. Catering services and provision stores will be located in the block. Additional ancillary spaces in the accommodation block will include the following:

- Clinic
- Control Room and Emergency Response Base
- Offices
- Male/female change rooms and laundry
- Technical equipment rooms and duty lockers

The air conditioning and ventilation system in the accommodation block will be designed for 25 years in accordance with industry standards and guidelines. The accommodation spaces will be pressurized to +50 pascals relative to the external atmospheric pressure. Differential pressure transmitters will be provided at each deck level within the accommodation block, and alarms will be raised in the Central Control Room (CCR) in the event of a loss of pressurization inside the accommodations. Entrance into the accommodation block will be completed via an airlock. The airlock will be provided with two doors; the design of this two-door airlock system will facilitate the accommodations remaining pressurized and will prevent outdoor air from entering in the accommodation block when outer doors are open. The outer door will be at a minimum weather tight while the inner door will be the self-closing type. The linings and ceiling used in the airlock will be constructed with air-sealed joiner panels.

The accommodation spaces will also be equipped with fire and gas detection systems. In the CCR, there will be a direct line of sight to the fire and gas monitors from the operators' positions.

[16] A superintendent-type cabin is a one-person cabin. Regular sleeping cabins are typically shared.

With regards to passive fire protection, class and other flag state requirements will be used to determine the necessary structural fire protection.

At a minimum the following spaces will be at least A-60 insulated, which is a noncombustible, thermal insulation designed for use on ships:

- CCR
- Galley
- Accommodation Equipment Room
- Telecom Equipment Room
- Computer Equipment Room

The forward-facing bulkhead of the accommodation block will be marine-grade H-60[17] insulated up to the C-deck and A-60 insulated for everything beyond the C-deck. All doors and windows located in this bulkhead will have the same insulation rating as the bulkhead in which they are installed. In general, all windows within the accommodation block are expected to have the same fire integrity as the wall in which they are installed. The entire window unit will be gas tight and weatherproof and have a minimum blast resistance of 0.5 barg.[18] The blast wall (an extension of the forward accommodation bulkhead) will be A0 rated and will run transversally up the sides of the vessel and vertically from the main deck to the D-deck. Structural deckhouse extensions forward of the accommodation front bulkhead and unprotected deckhouse areas 3 meters (9.8 feet) aft of the accommodation front bulkhead will also be H-60/A-60 protected in the event of a fire. An H-60 fire rating means it is capable of maintaining integrity and load bearing for 120 minutes and the insulation performance will last for 60 minutes, compared to the A-60 fire rating with a 60-minute integrity and load bearing capability and insulation performance.

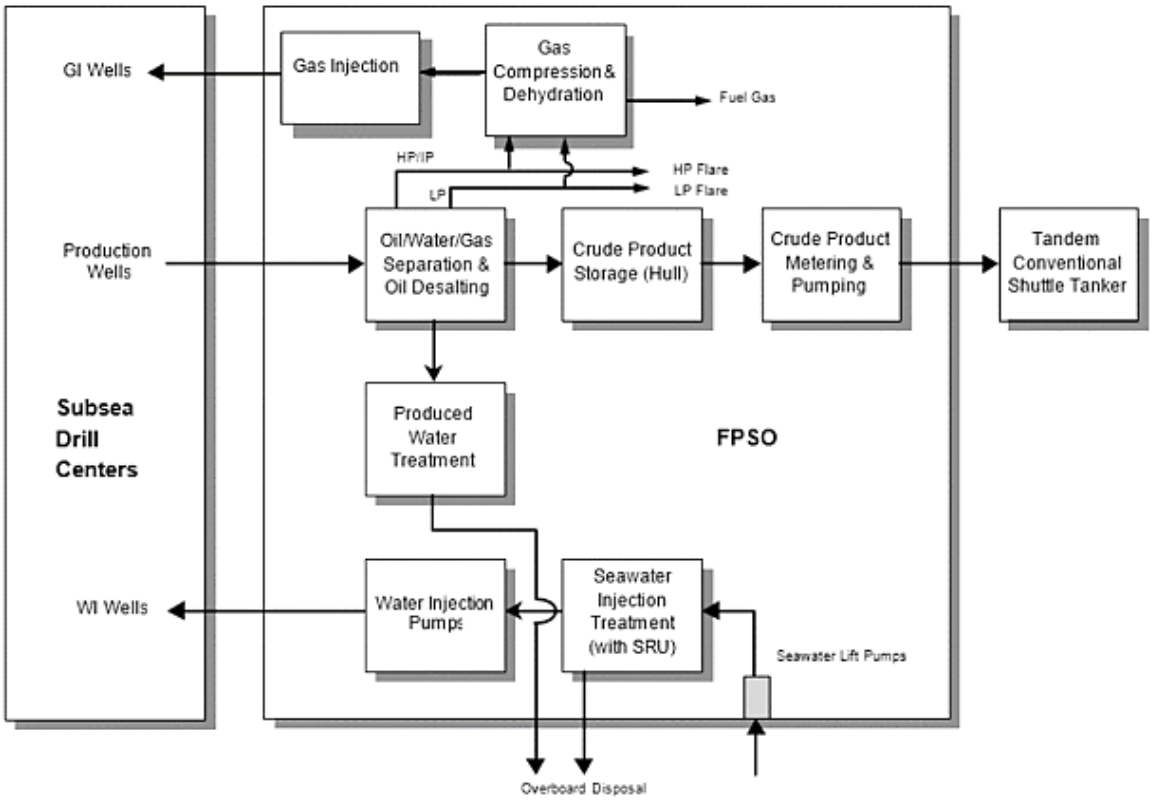
The following signage within the accommodation block will be photo-luminescent at a minimum to indicate the following:

- Emergency exit signs on emergency exit doors;
- Push/pull signs or handle position signs on emergency exit doors;
- Exit signs on high traffic area doors such as mess room, recreation room, and conference room;
- Direction markers indicating escape routes positioned at low levels in corridors and escape ways;
- Signs indicating route to and direction of internal stairways;
- Signs indicating route to and direction of external stairways; and
- Signs indicating directions to the lifeboat loading areas.

[17] If subjected to the standard fire test for 60 minutes, has an average temperature rise on the unexposed side of the insulated bulkhead or deck of less than 139°C (250°F) above the temperature before the standard fire test and has a temperature rise at any point on the unexposed surface, including any joint, of less than 180°C (325°F) above the temperature before the standard fire test. *Source: Mobile Offshore Drilling Units, 46 [U.S.] CFR 107-109 (2013)*
[18] Barg pressure is the pressure, in units of bars, above or below atmospheric pressure.

2.7.4. FPSO Process Systems

The process facilities on the FPSO topsides are shown schematically on Figure 2.7-2 and are described in the following sections.



GI = gas [re]injection; HP = high pressure; IP = intermediate pressure; LP = low pressure; SRU = Sulfate Removal Unit; WI = water injection

Figure 2.7-2: FPSO Topsides Process Flow Diagram

As described in the sections below, various aqueous streams are generated as part of FPSO topsides operations. For ease of review, the following provides a brief description of these streams:

- **Produced Water—**Produced water is a general term used to describe the water that comes from the reservoir (i.e., along with recovered hydrocarbons). Produced water will be discharged overboard after being treated to the discharge specification of less than 42 mg/L daily or 29 mg/L monthly average oil-in-water content. Off-specification produced water will be re-routed for further treatment prior to discharge.
- **Slop Water—**Slop water (also referred to as “slop tank water”) is made up of process effluent streams and surface runoff from all areas and oily drains on the FPSO main deck that is routed to a slop tank through gravity drains. The slop system is capable of treating

the slop water (via heat-assisted two-stage gravitational separation) such that the overboard discharge will not exceed 15 parts per million (ppm) oil content.

- **Stripping Water—**Each cargo oil tank is fitted with a stripping eductor. The water from the slop tanks used to drive the stripping eductors and strip the cargo tanks below 100 millimeters (4 inches) to prepare the cargo tank for entry is defined as “stripping water.” The resulting oily water mixture from the bottom of the tank is routed back to the slop tanks for treatment and discharge in accordance with slop water discharge specification (less than 15 ppm oil-in-water content).
- **Wash Water—**Wash water is a term that is used specifically to describe water that is used for desalting the crude. Wash water is filtered seawater that has been demineralized via reverse osmosis membranes. The aqueous streams resulting from the crude desalting process are combined with produced water and discharged overboard after being treated to the discharge specification of less than 42 mg/L oil-in–water content.
- **Bilge Water—**Bilge water is made up of water that may accumulate in the low point areas of the machinery spaces within the vessel due to condensation, washing, firefighting, etc. It is collected in bilge wells and subsequently routed to the bilge holding tank. From there, bilge water is sent to the bilge water separator unit for oil/water separation, with separated water (meeting the specification of less than 15 ppm oil-in-water content) discharged overboard and separated oil sent to the oily bilge tank. Oil and sludge from the oily bilge tank is pumped to an International Maritime Organization (IMO) shore connection, where it can be discharged to a tote tank or to an offshore support vessel for onshore disposal.
- **Sewage (Grey and Black Water)—**The sewage treatment system is comprised of separate sanitary drain collection networks provided for grey and black water streams and sewage treatment facilities, including a grey water treatment tank, a black water sewage treatment plant (STP), ultraviolet sterilization, and optional chlorination/de-chlorination dosing facilities. The treated black water effluent stream is sterilized by ultraviolet treatment as the primary method, with an option to chlorinate using the STP’s dosing pumps as a secondary method. Where chlorination of treated black water is employed, the treated black water will be discharged overboard with a total residual chlorine concentration as low as practical, but not less than 1 ppm. Grey water discharges from all sources combined (except for food waste from the galley macerator) are combined and dosed with chlorine automatically via the chlorine dosing system just before entering the grey water treatment tank, from which the tank contents will be discharged overboard.

2.7.4.1. Oil Processing System Overview

An inlet manifold is required to receive full wellstream-produced fluids from the reservoir (consisting of oil, gas, and water) via the production flowlines, and to route the fluids to the FPSO processing facilities. The full wellstream-produced fluids will be separated into oil, water, and gas phases. Wash water will then be added to the stabilized crude oil to remove dissolved salts as part of what is known as “oil desalting.” An electrostatic coalescer is also employed in crude oil dehydration and desalting. The final crude oil from the separation/stabilization process

will be treated to meet the specifications for sale prior to being sent to the crude oil storage tanks in the FPSO hull.

The oil processing system consists of a single oil processing train and a test separator located on the main deck of the FPSO. The oil processing train main components are shown on Figure 2.7-3.

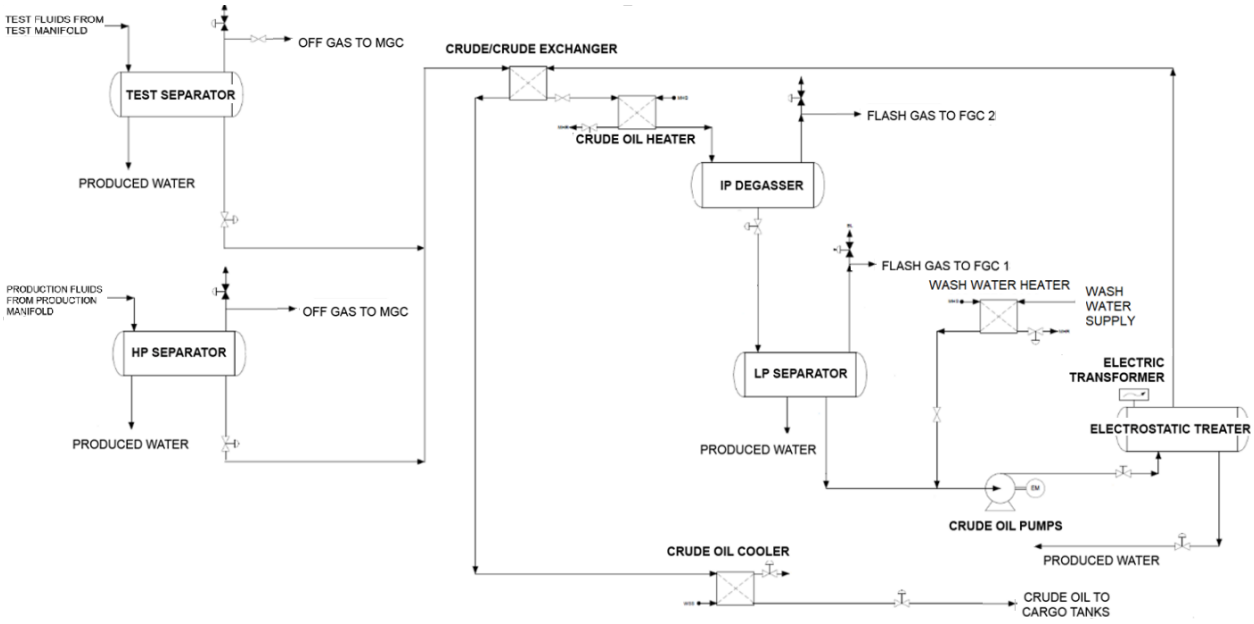


Figure 2.7-3: Simplified Oil Processing Schematic

The test separator is provided for well testing and well clean-up activities. The oil processing train incorporates three stages of separation to produce stabilized and dehydrated crude, as well as gas subsequently used for fuel and re-injection. Once stabilized and dehydrated sufficiently, the crude oil stream from the oil processing system is routed to the FPSO cargo tanks. Produced water from the oil processing system is routed to the produced water system, where it is treated to facilitate meeting the oil-in-water content discharge specification prior to disposal overboard.

Facilities will be provided for online removal of completion fluids and solids (commonly called de-sanding facilities) from the test separator. De-sanding equipment will be skid-mounted and designed to allow for transportation of solids from well cleanup between the FPSO and onshore facilities. The completion fluids and solids are anticipated during initial production well ramp-up, and these facilities will mostly operate intermittently for the early production years during the start-up of the wells. The test separator is equipped with flushing nozzles, where the de-sanding facilities will be connected, and internals that will facilitate solids fluidization. The High Pressure (HP) Separator is also equipped with both flushing nozzles and internals for future connection to the de-sanding facilities, if required.

For completion fluid handling, fluids flushed out of the test separator via the flushing nozzles will be routed to a surge vessel in the de-sanding facilities. Then, the completion fluids will be

transferred to ISO (International Organisation for Standardisation) tanks for later onshore disposal. For solids handling, filtered seawater from reverse osmosis charge pump(s) discharge will be used as jetting water to flush the test separator via the flushing nozzles. Oxygen scavenger will be injected in the seawater to avoid any oxygen ingress into the oil train separation. The flushed solids from the test separator, along with jetting seawater and produced water, will be routed to well clean-up fluid facilities. The solids will be separated using a hydrocyclone/accumulator skid and finally transferred into sand-bagging tanks for later onshore treatment and disposal (sand will be subjected to onshore thermal treatment as needed for hydrocarbon removal, followed by landfill disposal of the treated waste stream). The estimated quantity of sand that will be generated for disposal is on the order of 3 to 5 barrels (bbl) (0.5 to 0.8 m^3) of sand per well. Remnant water will be routed back to the oil train separation upstream of the crude/crude exchanger. Figure 2.7-4 is a schematic of the de-sanding process.

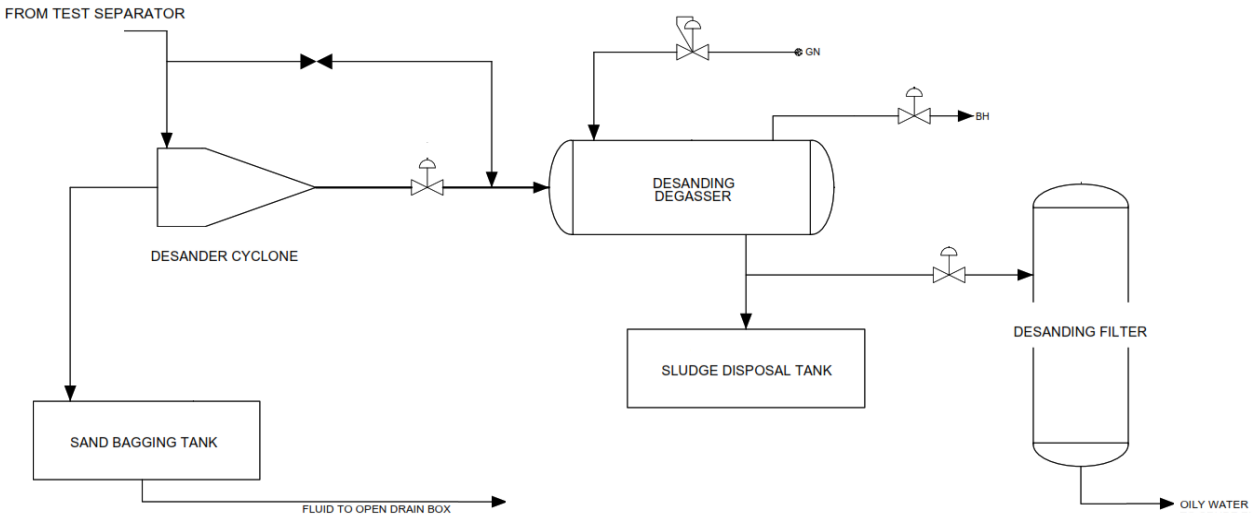


Figure 2.7-4: Simplified De-sanding Schematic

Further processing of the water and gas streams from the separation process and the process for treating seawater for injection are described below.

2.7.4.2. Gas Processing

Associated gas from the oil separation and treating process will be compressed and dehydrated to provide fuel gas. Surplus gas will be re-injected into the reservoirs. The purpose of the FPSO gas processing system therefore is to condition the associated gas (that which is not consumed as FPSO fuel gas) to the appropriate specification prior to re-injection into the reservoir. The gas processing system comprises three stages of Flash Gas Compression, one stage of Main Gas Compression, one gas dehydration system, and two stages of export / re-injection gas compression.

Flash Gas Compression

The Flash Gas Compression system will be used to collect vapors from the low-pressure oil processing systems (e.g., intermediate-pressure and low-pressure separation) and utility systems (e.g., vapor recovery system, triethylene glycol [TEG] regeneration, produced water treatment). The Flash Gas Compression system will be designed to minimize flaring of hydrocarbon gases from low-pressure systems during normal operations. Low-pressure flash gas may be flared temporarily when a Flash Gas Compressor is down due to upset or maintenance. Installed spare compressors will be included to reduce flaring duration in these instances.

The Flash Gas Compression system will consist of a first-stage dry screw compressor driven by a fixed-speed electric drive, along with second- and third-stage centrifugal compressors with variable-speed electric drives. Upset or maintenance of a gas compressor may require gas to be flared temporarily to protect the safety of personnel and facilities. A key strategy integrated in the FPSO design to reduce the frequency and duration of non-routine flaring for upsets and maintenance on the compression system will be the inclusion of installed spare gas compression equipment capacity. During instances where one compression unit is offline for upset or maintenance, installed spare compression equipment can be used to allow partial or full production to continue while reducing volume and duration of flared gas. The gas compression sparing capacity provided in the Yellowtail Project design exceeds that included in the designs of prior EEPGL development project FPSOs.

For the Flash Gas Compression system, the design basis includes 2 x 100% (two at 100 percent capacity each) dry screw compressor capacity for first-stage compression and 2 x 100% (two at 100 percent capacity each) centrifugal compressor capacity for second- and third-stage compression.

The Flash Gas Compression system will be equipped with suction scrubbers, coolers, and associated capacity controls. The Flash Gas Compression system's main components are shown on Figure 2.7-5.

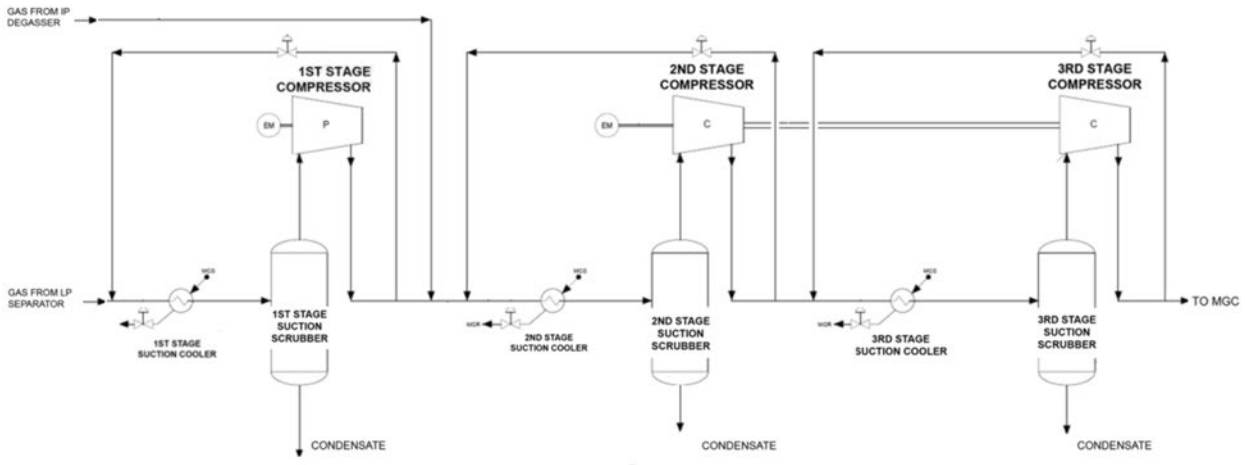


Figure 2.7-5: Simplified Flash Gas Compression System

Gas from the Low Pressure (LP) Separator is recovered by the 1st stage Flash Gas Compressor, which compresses gas to feed the 2nd stage Flash Gas Compressor. The 1st stage Suction Cooler cools down the gas, and then gas flows through the 1st stage Flash Gas Compressor suction scrubber before going to the compressor suction. Condensate from the 1st stage Flash Gas Compressor suction scrubber is routed back to the LP Separator using condensate pumps. Gas from the Intermediate Pressure (IP) Degasser and Produced Water Flash Vessel is recovered by the 2nd stage Flash Gas Compressor and, together with the gas from the 1st stage Flash Gas Compressor, is further compressed in the 3rd stage Flash Gas Compressor prior to feeding into the Main Gas Compressor. The 2nd stage Suction Cooler cools down the gas, which then flows through the 2nd stage suction scrubber before going to the 2nd stage compressor suction. Condensate from the 2nd stage suction scrubber is routed to the IP Degasser. After 2nd stage compression, the gas is then cooled down at the 3rd stage Suction Cooler, and then it flows through the 3rd stage suction scrubber to the final stage of Flash Gas Compression. Condensate from the 3rd stage suction scrubber is routed to the IP Degasser.

Main Gas Compression

The purpose of the Main Gas Compression system is to compress gas from the HP Separator and the Flash Gas Compressor system to a pressure where it can be processed through the dehydration system and supply fuel gas at an appropriate pressure. The Main Gas Compression system will be equipped with the appropriate suction scrubbers, coolers, and associated capacity controls. The Main Gas Compression system's main components are shown on Figure 2.7-6.

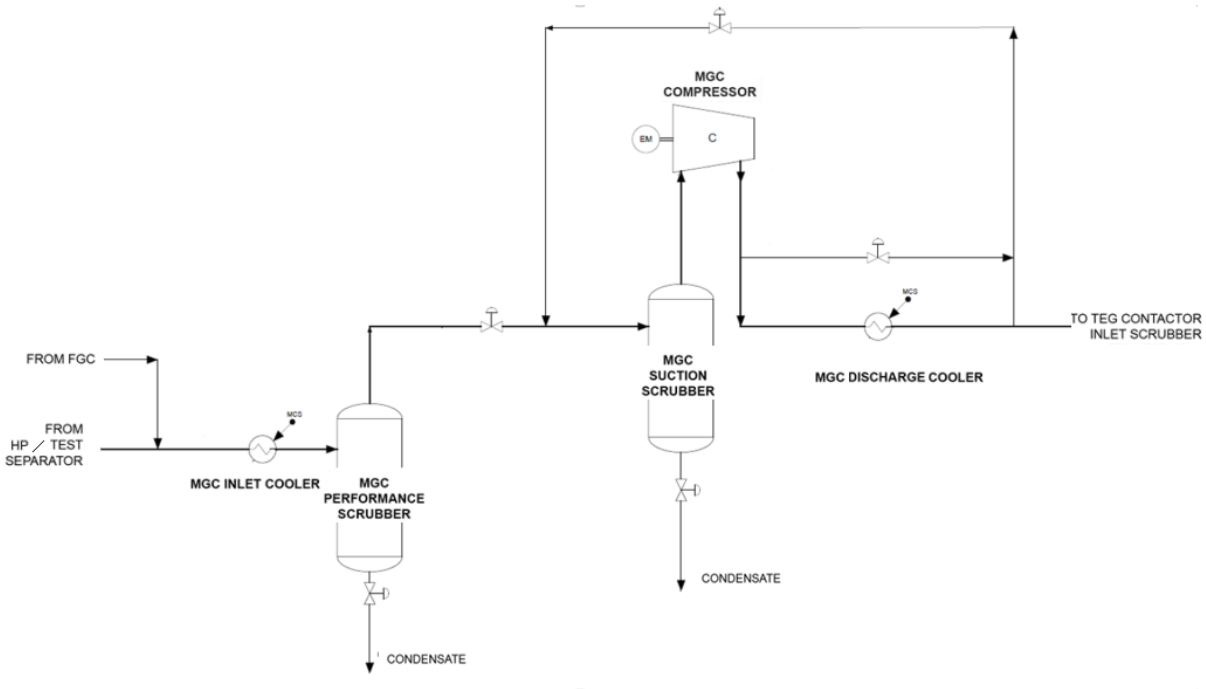


Figure 2.7-6: Simplified Main Gas Compression System

Gas from the Test Separator, HP Separator, and Flash Gas Compressors first is pre-cooled in the Main Gas Compression Inlet Cooler, and then passes through a Main Gas Compression Performance Scrubber to enter the Main Gas Compression system. For the Main Gas Compression system, the design basis includes 3 x 50% (three at 50 percent capacity each) capacity for each system. The 3 x 50% design for the Main Gas Compression and Gas Re-injection systems was selected so that when one train is down, the second train can continue to operate until the installed spared compressor train is online. This three-train configuration was selected to enhance the facility's safety, minimize flaring, and reduce production down time. The two Main Gas Compression trains in normal operation and one spared train contain a suction scrubber, a compressor, and a discharge cooler. The compressor boosts the gas pressure before routing gas to the gas treatment package. Each Main Gas Compression Train Compressor is a single-stage, fixed-speed, electrically driven, centrifugal type of compressor.

Gas Treatment System

Gas treatment is designed to reduce the water content within the gas to prevent hydrates in the subsea Gas Re-injection System (see Figure 2.7-7). The water content specification required is achievable with a conventional TEG regeneration unit using a re-boiler and gas stripping column and is driven by future gas lift requirements as opposed to gas injection requirements.

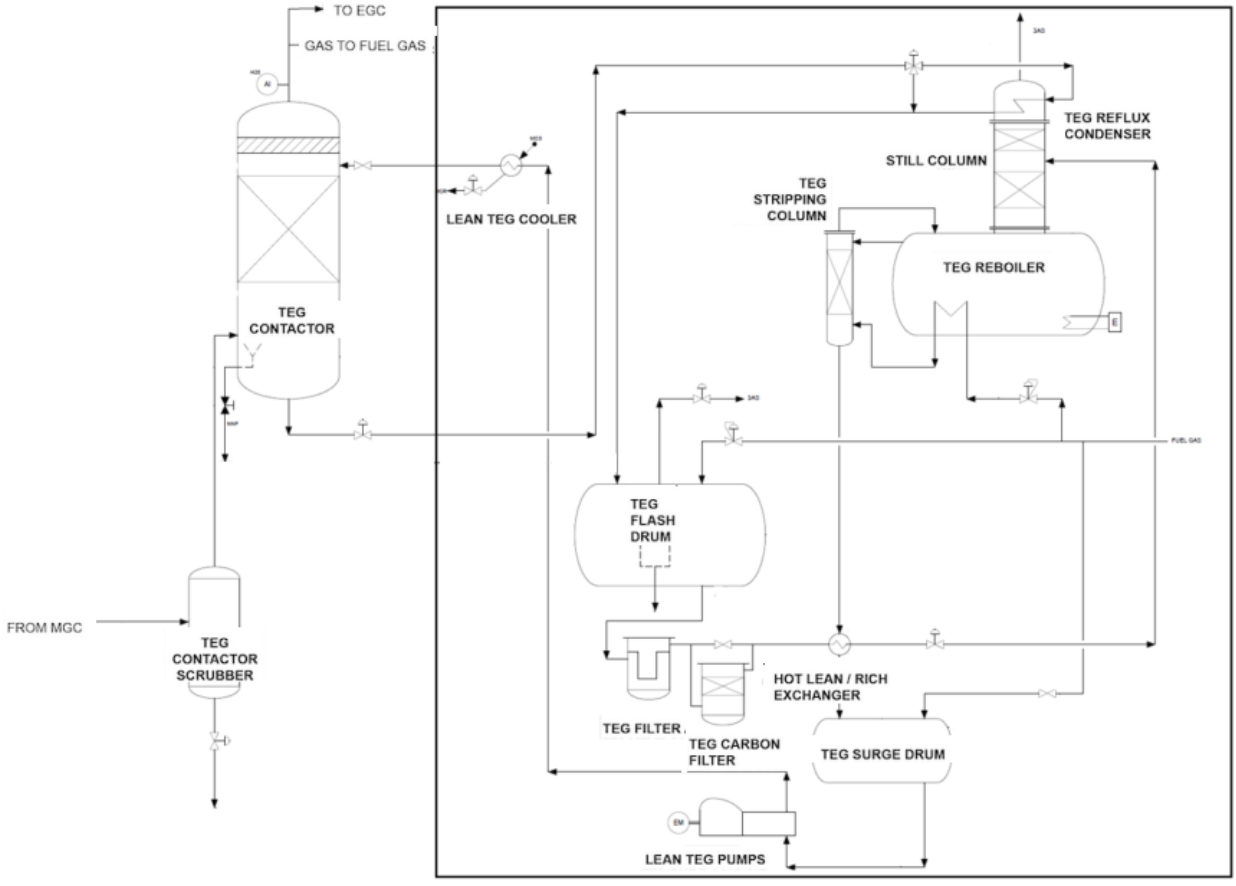


Figure 2.7-7: Simplified Gas Treatment System

Fuel Gas

The fuel gas system will provide fuel gas to all electrical power generation and mechanical service gas turbines. In addition, the fuel gas system will provide fuel gas to all other low-pressure users (pressure control of vessels, TEG regeneration gas stripping, etc.). The fuel gas system will be adequately designed to achieve the fuel gas treating specifications for all fuel gas users as required by their respective equipment vendors under all normal operating, upset, and start-up conditions. The fuel gas system will be adequately sized to allow switch over from fuel gas to diesel fuel without tripping the gas turbines.

Export and Injection Gas Compression

The purpose of the export and injection gas system is the compression of dehydrated gas to an appropriate pressure where it can be re-injected into the reservoir. The export and injection gas system will be equipped with suction scrubbers, coolers, and associated capacity controls.

The export and injection gas system's main components are shown on Figure 2.7-8. Gas from the gas treatment system feeds the export and injection gas system. The export and injection gas system includes the export gas compressor and injection gas compressor. The export gas compressor contains a suction scrubber, a centrifugal-type of compressor, and a discharge cooler. The system will be designed to allow for potential future offtake from the discharge of the export compressor for potential future gas lift / gas export. However, there are currently no plans to export gas from the Project.

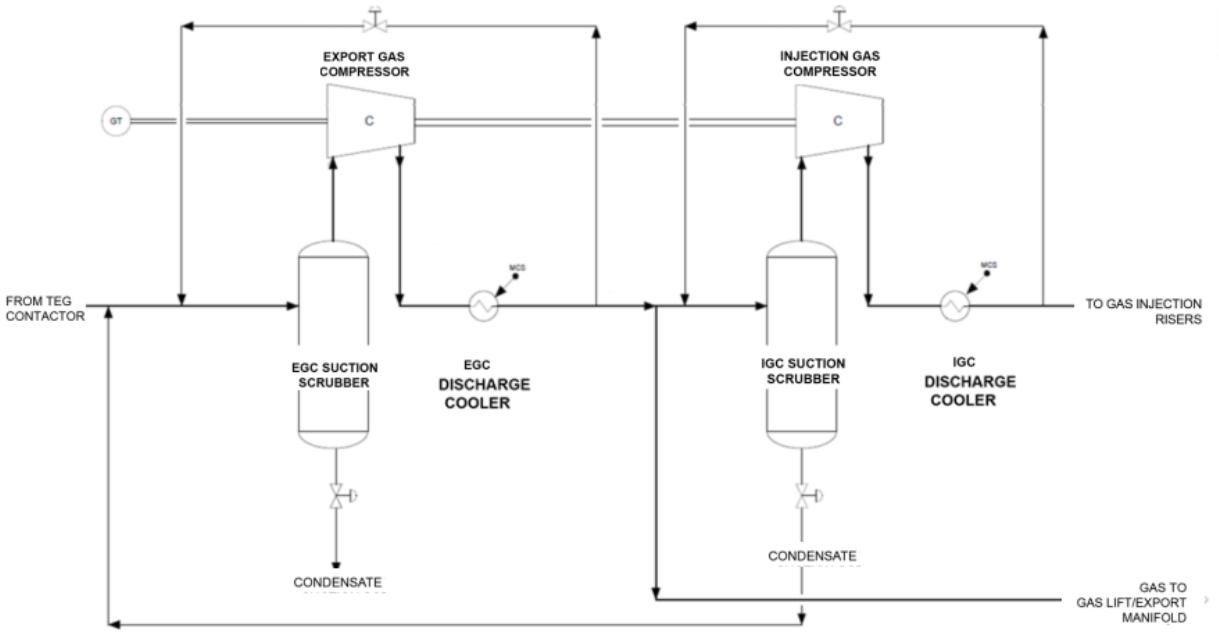


Figure 2.7-8: Simplified Export/Re-Injection Gas Compression System

Gas from the export gas compressor discharge cooler is routed to the injection gas compressor system, which consists of a suction scrubber, a centrifugal-type of compressor, and a discharge cooler. Gas is compressed to meet the injection pressure requirement. The discharge cooler cools the gas before sending the gas to re-injection subsea.

As described above, the FPSO will incorporate two trains of export / re-injection gas compression in normal operation plus a spare with a design basis of 3 x 50% (three at 50 percent capacity each) capacity, where the export gas compressor and injection gas compressor are driven by a common mechanical drive. The 3 x 50% design was selected so that when one train is down, the second train can continue to operate until the installed spared compressor train is online. This three-train configuration was selected to enhance the facility's safety, minimize flaring, and reduce production down time.

2.7.4.3. Flare and Blowdown System

A flare system will be provided for the collection and safe disposition of produced hydrocarbon gases. The flare system will include both a high-pressure and low-pressure flare. The flare system will be designed to safely accommodate flaring of associated gas during start-up and shutdown; equipment maintenance and process upsets scenarios; emergency pressure relieving scenarios, including facility blowdown; and other non-routine flaring events, including blowdown of the subsea Gas Re-injection System. Discharges from pressure relief valves, blowdown valves, and other hydrocarbon streams will be routed to the flare system for safe disposal when needed. While the flare system is designed for no routine flaring of associated gas, which is instead re-injected, the preliminary design includes a *de minimis* level of continuously flared sources including:

- Pilot gas, purge gas, and back-up gas systems critical to the safe and reliable operation of the flare; and
- Primary vent gas from compressor dry gas seals, analyzers, cooling medium/heating medium/chemical tanks blanket gas and potentially other *de minimis* sources, which are not practical to recover for routing to the vapor recovery unit (see below).

An even smaller compressor seal gas system stream, consisting of secondary seal gas, and gas from flexible production risers, are not practical to route to the flare and vent to atmosphere. The design of these systems is typical for the industry.

As described above, upset or maintenance of a gas compressor may require gas to be flared temporarily to protect the safety of personnel and facilities. A key strategy integrated in the FPSO design to reduce the frequency and duration of non-routine flaring for upsets and maintenance on the compression system will be the inclusion of installed spare gas compression equipment capacity. During instances where one compression unit is offline for upset or maintenance, installed spare compression equipment can be used to allow partial or full production to continue while reducing volume and duration of flared gas. The gas compression sparing capacity provided in the Yellowtail Project design exceeds that included in the designs of prior EEPGL development project FPSOs.

2.7.4.4. Vapor Recovery Unit

A VRU will collect vapors from the Cargo Tanks and other low-pressure sources. The low-pressure sources captured by the VRU will include vapors coming from the TEG regeneration and produced water treatment systems (vapors that would otherwise be directed to the flare). The discharge from the VRU will be fed to the Flash Gas Compression system.

2.7.4.5. Produced Water Treatment

Produced water is water that is produced as a byproduct during the extraction of oil and natural gas. Oil and gas reservoirs nearly always contain water as well as hydrocarbons, sometimes in a zone that lies under the hydrocarbons and sometimes in the same zone with the oil and gas. There are two primary options for the disposition of produced water: it can either be treated and discharged overboard or it can be combined with seawater and re-injected. Overboard discharge of treated produced water was selected for the Yellowtail Development Project based on a best available technology (BAT) analysis, which is described in Section 2.18.3.5, Produced Water Treatment. Note that the potential environmental impacts on water quality from overboard discharge of treated produced water were assessed as Negligible (see Table 6.4-10). Modeling conducted for the EIA indicates a 98.2 percent reduction in oil and grease and other residual production chemicals within 100 meters (328 feet) of the discharge.

The produced water treatment system will be designed to collect produced water from process facilities and to treat the water for discharge overboard. The produced water treatment equipment is designed to reduce freely dispersed oil content present in the produced water from the Production Separator to achieve the required outlet water specification: oil-in-water content—29 mg/L (monthly average), 42 mg/L (daily maximum). This performance is guaranteed by the selected equipment supplier for all normal operating conditions. The produced water treatment system will be maintained and operated to maximize oil recovery from the produced water prior to discharge. Produced water that does not meet the overboard discharge specification after treatment will be routed to an appropriate tank in the hull and managed as described in Section 2.7.10.1, FPSO Cargo Systems.

The Produced Water Treatment System main components are shown on Figure 2.7-9.

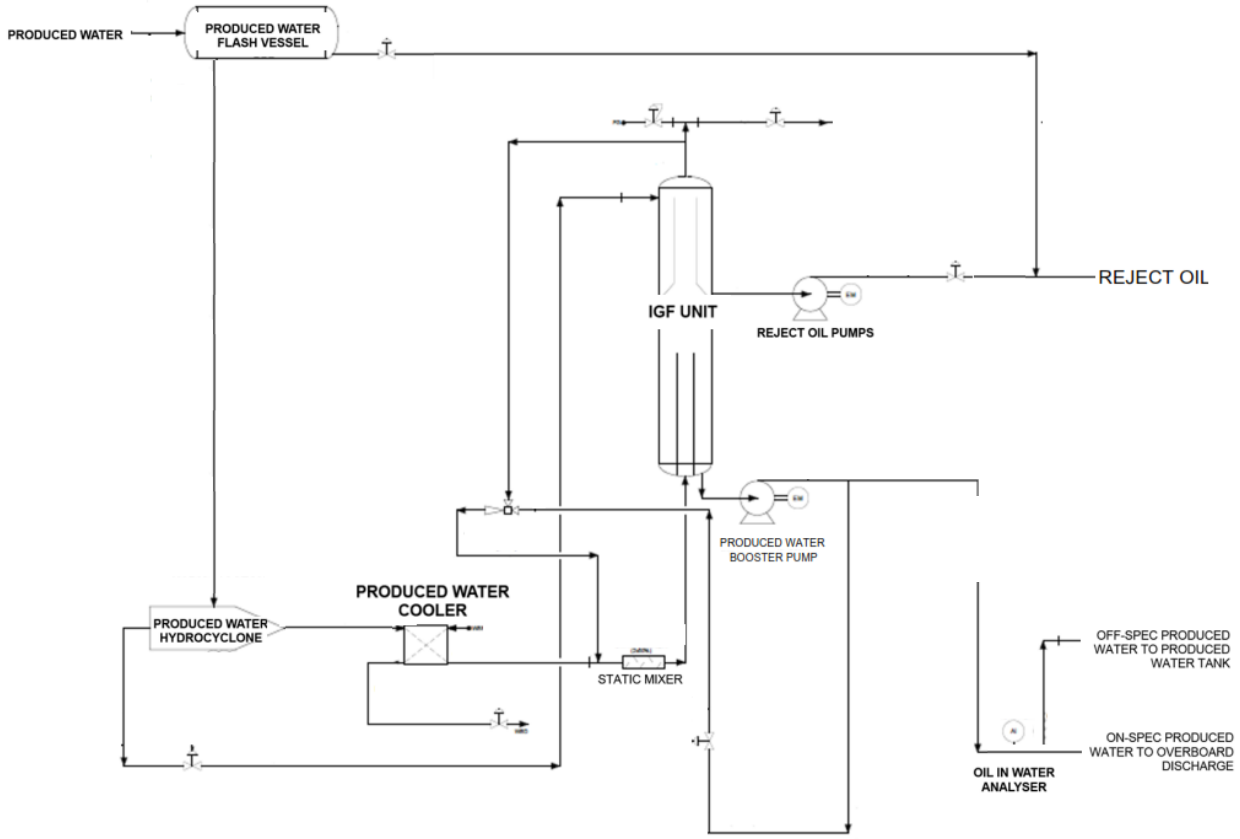


Figure 2.7-9: Simplified Produced Water Treatment System

Produced water from the Electrostatic Treater is normally routed to the Produced Water Flash Vessel, with an option of being routed to the LP Separator for pre-wash when emulsion risk is low, while produced water from the HP Separator and LP Separator is routed directly to the Produced Water Flash Vessel. Gas flashed from the produced water is routed to the 2nd stage Flash Gas Compressor. From the Produced Water Flash Vessel, the water is routed to the Produced Water Hydrocyclones, where the bulk oil is separated.

Hydrocyclones have been used for years as a device to separate oil from produced water. They are gravity-separation devices that use centrifugal force to increase the gravitational field, thus greatly increasing the effect of “buoyancy” on the oil droplets. Hydrocyclones are highly efficient at removing oil from produced water, do not contain moving parts, and are insensitive to motion and orientation.

From the Produced Water Hydrocyclones, the produced water then goes through Produced Water Coolers to cool the water before flow is sent to the Induced Gas Flotation Units, where the remaining freely dispersed oil is separated to facilitate oil content being met. Separation in the Produced Induced Gas Flotation Units is enhanced by the addition of gas to the inlet stream via an eductor. The gas and produced water are passed through a static mixer, where small

micron-size bubbles are formed and uniformly distributed. This facilitates gas being entrained into the entire feed stream to the Induced Gas Flotation Units. The bubbles attach to the oil and solids particles present in the incoming feed. This gas helps coalesce the oil and enhance separation inside the Induced Gas Flotation Units.

Oil rejected from Produced Water Hydrocyclones is routed to the oil bucket in the Induced Gas Flotation Units. Reject oil from Induced Gas Flotation Units is routed back to the Oil Processing System upstream of the Crude Oil Heater. Each Induced Gas Flotation Unit will have a dedicated online oil content analyzer that provides continuous oil content monitoring for the treated produced water stream. The control system will automatically route water to the off-spec tank if an oil content of 42 mg/L is exceeded. The off-spec tank (approximately 9,700 m^3 capacity) is the only location on the FPSO where produced water will be stored (on a temporary basis). The online analyzer is an inline device that uses fluorescence to provide continuous accurate measurements of oil concentrations in water. Once the automated system routes the produced water stream to the off-spec tank, it remains in that mode until such time as the operator returns the system back to overboard discharge mode. This will occur once the operator confirms that issues with the produced water treatment system have been rectified and the produced water stream is meeting overboard discharge specifications. From the off-spec tank, the produced water will be returned to the topsides Induced Gas Flotation Unit for further treatment. In the event of unavailability of the off-spec tank, the produced water will be transferred to slop tanks. If the produced water is routed to the slop tanks, any overboard water discharge from the slop tanks will not exceed 15 ppm oil content.

2.7.4.6. Seawater Treatment and Water Injection System

To increase oil recovery, water is injected into oil reservoirs to refill the voidage created by the removal of oil and natural gas and to help direct oil to the producing wells. The FPSO is designed for injection of seawater to assist with oil recovery so that voidage can be managed starting closely after commencement of production from the reservoir(s).

Seawater used for water injection will be treated prior to injection into the producing reservoirs. Seawater lift pumps on the FPSO will be used to pump seawater from depths up to 100 meters (328 feet) below the surface to access colder seawater than is available from the shallower depths. The filtration system will remove particulate from the incoming seawater. Following filtration, the seawater will be treated to remove dissolved oxygen and sulfate ions. The treated seawater will then be pumped at the pressure necessary for injection into the reservoir.

A portion of the treated seawater will be further treated through a reverse osmosis system to make wash water. Wash water is required for removal of salt from the crude oil as part of oil de-salting, as described in Section 2.7.4.1, Oil Processing System Overview.

The main components of the seawater treatment system are described below and depicted on Figure 2.7-10:

1. Coarse and Fine Filtration—Seawater is lifted via Seawater Lift Pumps, the seawater passes through Coarse Filters to remove 98 percent of the particles bigger than 80 micrometers (µm), then seawater goes to Fine Filtration, where 95 percent of the particles bigger than 0.03 µm are removed by the Ultrafiltration Membrane.
2. Sulfate Reduction of Injection Water—Seawater leaving the Ultrafiltration Membrane is boosted in pressure using the HP Feed Pumps, which provide the required pressure for the Sulfate Removal Package (SRP) Membrane Units. These pumps are American Petroleum Institute 610 centrifugal pumps driven by fixed-speed electric motors. Removal of sulfates from the oxygenated injection water is done by the SRP Membrane Units.
3. Deaeration—Seawater from the SRP Membrane Units is fed to the Deaeration Column, where dissolved air is removed from the seawater. Mechanical deaeration is achieved to a specification of approximately 50 parts per billion oxygen using a Vacuum Package. Final deoxygenation to the required specification of 20 parts per billion oxygen is achieved by injection of oxygen scavenger.
4. Water Injection Booster Pumps—Treated seawater from the Deaeration Column is fed to the Water Injection Booster Pumps. From the Water Injection Booster Pumps, treated water goes through the Cooling Medium Coolers.
5. Water Injection Pumps—Treated seawater from the Cooling Medium Coolers is fed to the Water Injection Pumps. Water leaves the FPSO via water injection risers at the required injection pressure supplied by Water Injection Pumps. These are multi-stage American Petroleum Institute 610 centrifugal pumps driven by fixed-speed, electric motors.

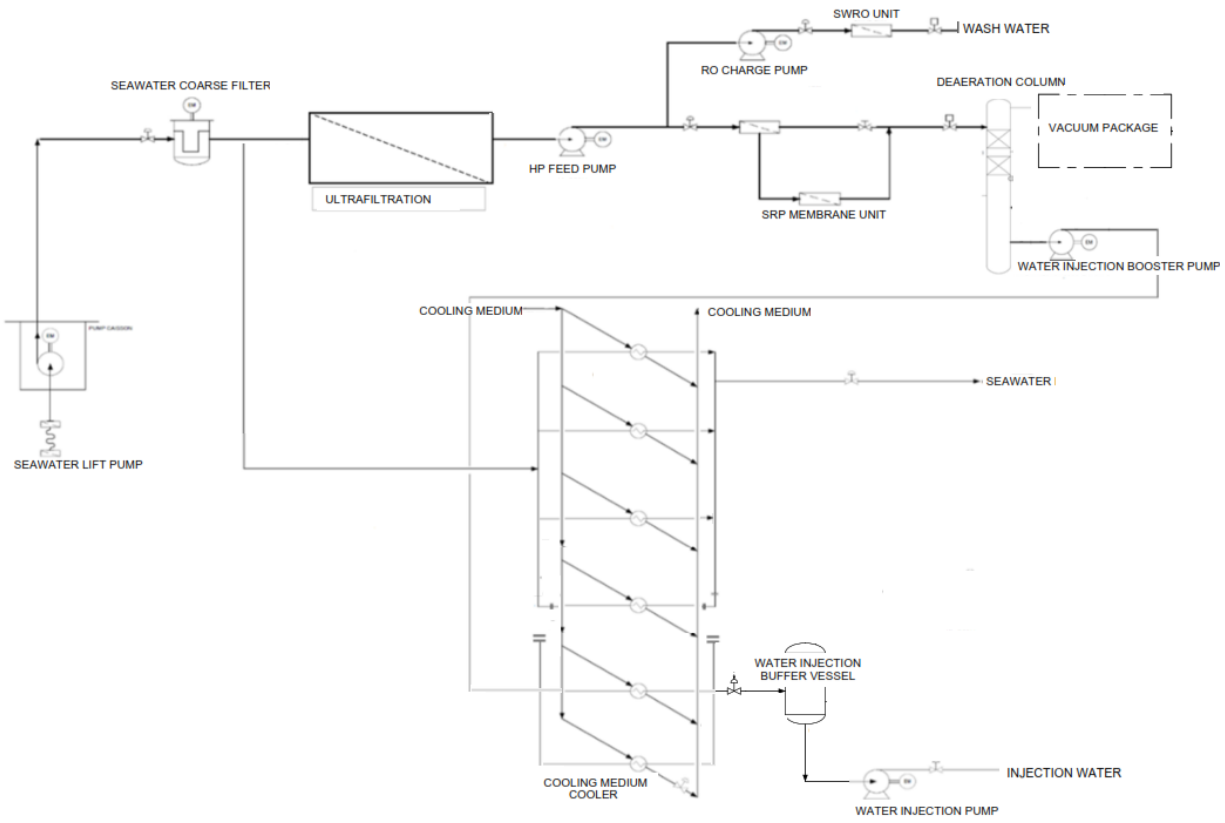


Figure 2.7-10: Simplified Seawater Treatment System

2.7.4.7. Slop Water System

All the main drain streams are collected by a slop tank on the port side of the FPSO (referred to as “Slop Tank (PS)”). A separate slop tank on the starboard side of the FPSO (referred to as “Slop Tank (SB)”) receives only settled water from Slop Tank (PS) through a decanting line. The hazardous and non-hazardous open drain headers are directed to Slop Tank (PS) via liquid seals and will be isolated. Two-stage gravitational separation (first stage—Slop Tank (PS), second stage—Slop Tank (SB)), assisted by slop tank heating, will result in slop water with a low oil-in-water content. The separated oil in each tank is transferred to a cargo tank via the transfer header, using each tank’s slop tank oil-skimming pump. Slop water from Slop Tank (SB) passes through an Oil Content Monitor (OCM) package for automatic monitoring of oil-in-water content prior to overboard discharge. In the event that the OCM package detects an oil-in-water content above 15 ppm, the overboard discharge line will close and the recirculation line will open automatically; the off-specification slop water will then be recirculated back to Slop Tank (PS) via the hazardous open drain header. Prior to cargo oil tank entry, the cargo oil tanks can be cleaned with slop water via the crude oil washing header. For this purpose, preferably water from Slop Tank (SB) will be used. Figure 2.7-11 provides a process flow diagram for the slop system.

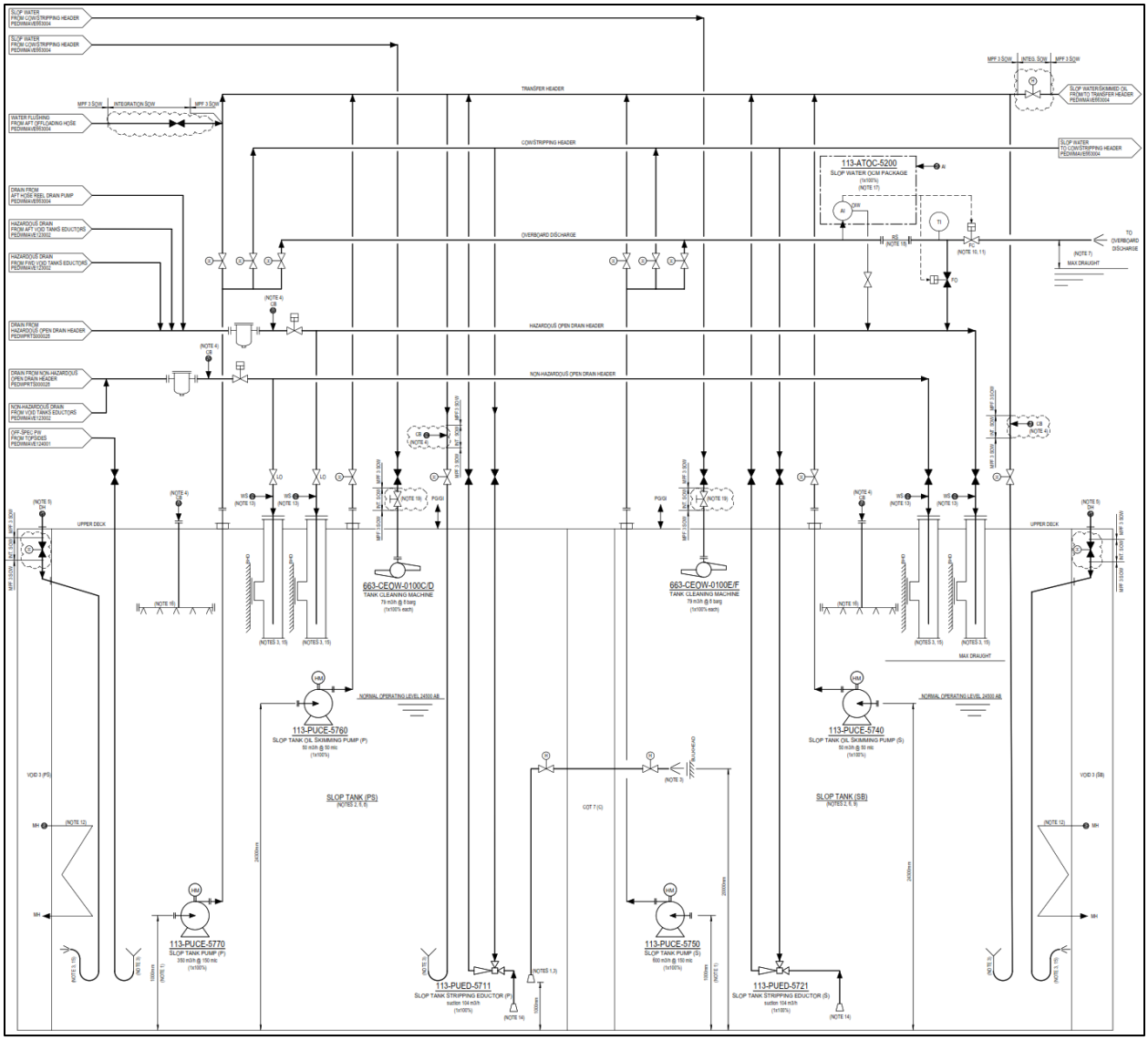


Figure 2.7-11: Slop System Process Flow Diagram

2.7.4.8. Bilge Water System

The bilge system is provided to dispose of oily water residue that may accumulate in machinery spaces and in various bilges throughout the vessel due to condensation, washing, maintenance, etc. It is also capable of controlling limited flooding in the aft machinery space, e.g., as a result of damage to piping systems. Bilge water collected in the machinery space bilge wells, double-bottoms, voids, cofferdams, etc., is transferred to the bilge holding tank using the oily bilge pump. Bilge water is sent from the bilge holding tank to the bilge water separator unit for oil/water separation, with separated water (with low oil-in-water content) passing through an OCM package for automatic monitoring of oil-in-water content prior to overboard discharge. In the event that the OCM package detects an oil-in-water content above 15 ppm, the overboard discharge line will close and the recirculation line will open automatically; the off-specification bilge water will then be recirculated to the Bilge Holding Tank. Separated oil is sent to the oily bilge tank. Sludge from the oily bilge tank is pumped periodically to a supply vessel, or tote tank, for ultimate onshore disposal. In addition to the Aft Machinery Space Bilge System, the Cargo Area Bilge System is used for dewatering the Cargo Block bilges (voids, cofferdams, etc.) and Forward Machinery Space. The Cargo Area Bilge system uses a network of eductors located in the various respective spaces to strip the bilges. The eductors are operated via seawater driving medium supplied by the General Service/Bilge pump. The stripped fluid is sent to the Slop Tank (PS) for processing through slop tank decanting and the overboard oil content monitor. Figure 2.7-12 provides a process flow diagram for the Aft Machinery Space Bilge System. Figure 2.7-13 provides a process flow diagram for the Cargo Area Bilge System.

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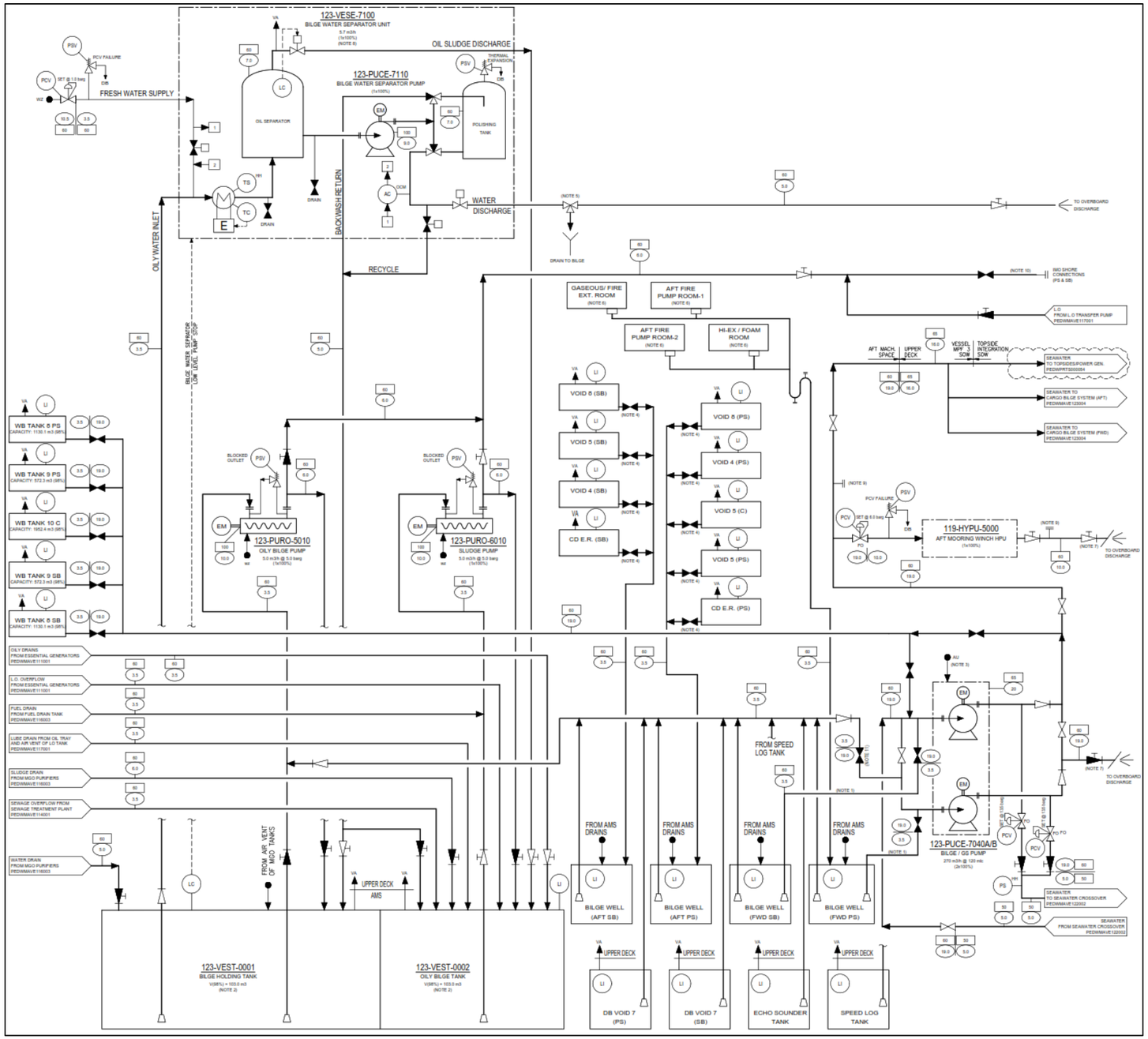


Figure 2.7-12: Aft Machinery Space Bilge Water System Process Flow Diagram

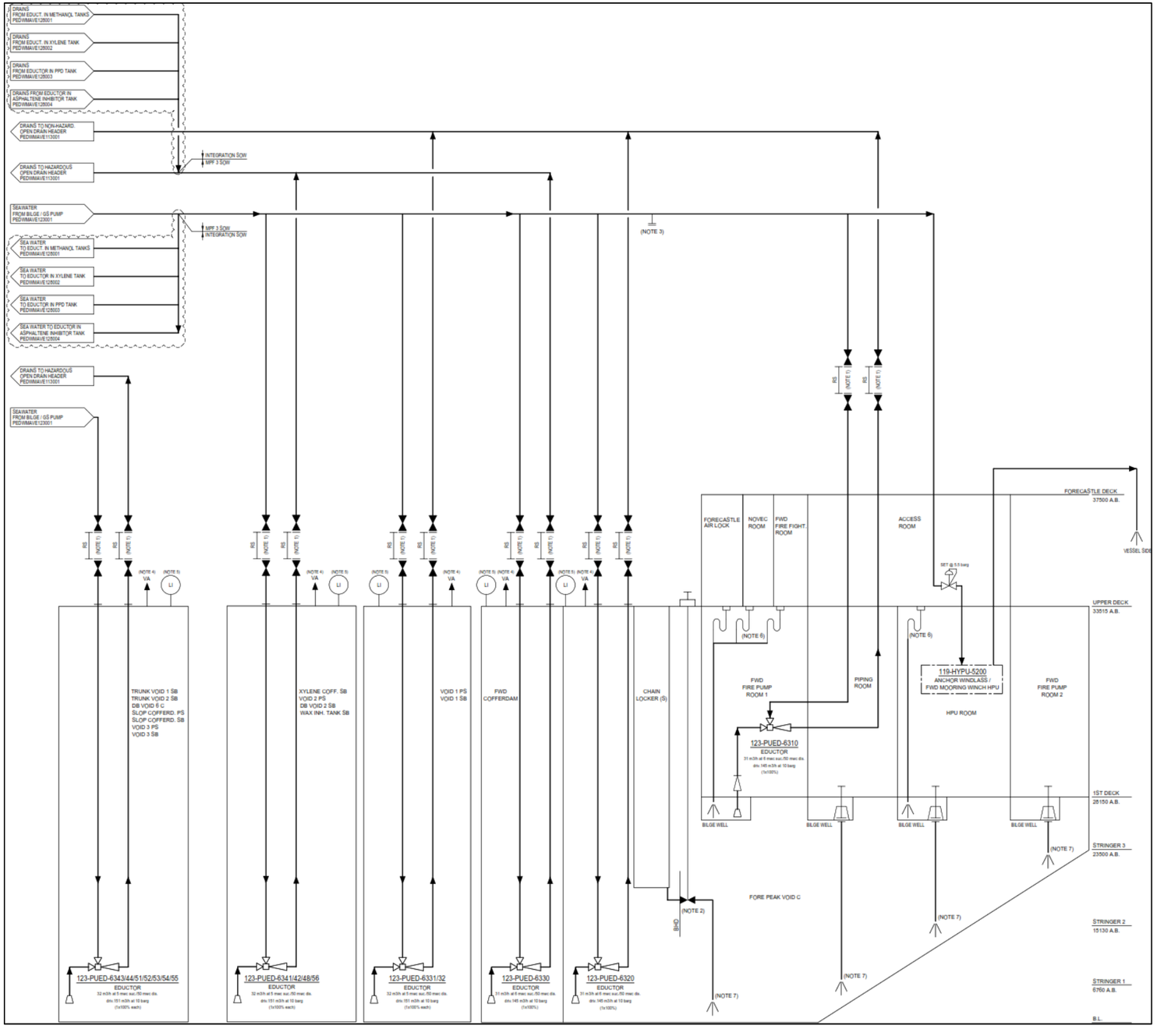


Figure 2.7-13: Cargo Area Bilge Water System Process Flow Diagram

2.7.4.9. Sewage Treatment System

The sewage treatment system is comprised of separate sanitary drain collection networks provided for grey water and black water waste streams and sewage treatment facilities, including a grey water treatment tank, chlorination / de-chlorination dosing facilities, and an STP. Black water discharges from all sources are sent to the STP's aeration tank for treatment. Black water treatment then continues inside the STP progressively, starting from the STP's aeration tank, then into its settling tank, and finally into its contact tank. The contact tank's contents are sterilized by ultraviolet treatment as the primary method, with an option to chlorinate using the STP's dosing pumps as a secondary method. Treated black water is discharged overboard via the STP overboard discharge points located on the port and starboard sides of the FPSO. Grey water discharges from all sources (except for food waste from the galley macerator) are combined and dosed with chlorine automatically via the chlorine dosing system just before entering the grey water treatment tank. Chlorination then continues inside the tank. At a pre-determined tank level set-point, the duty grey water pump will automatically start and pump out the tank contents overboard. In an upset condition, all sewage overflows from the affected sewage collection points (STP, grey water treatment tank, and/or grease trap/separator) will be sent to the oily bilge tank for collection and ultimate transfer to a supply vessel for eventual onshore disposal. Figure 2.7-14 provides a process flow diagram for the bilge system.

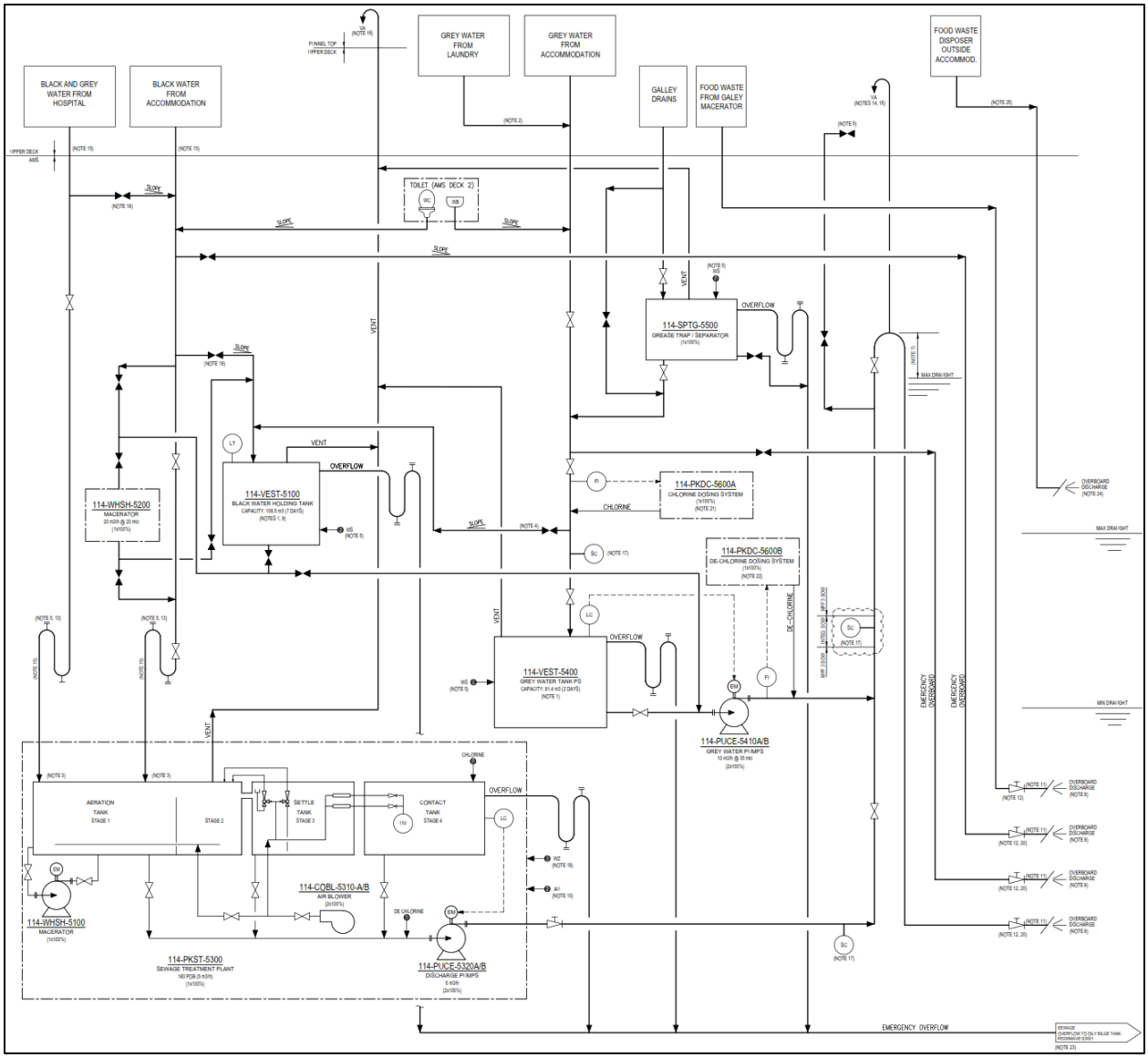


Figure 2.7-14: Sewage Treatment System Process Flow Diagram

2.7.5. FPSO Utility Systems

This section discusses the utility system requirements for the FPSO.

2.7.5.1. Process Cooling

Cooling of process streams via a closed-loop, water-based cooling medium system is required to dissipate heat generated by the oil and water treating systems, compression systems, and miscellaneous utility systems.

The seawater lifting system will supply the required seawater for cooling (see Section 2.7.4.6, Seawater Treatment and Water Injection System). Process hydrocarbon fluids will not come into contact with this seawater. After use in the cooling system, seawater will be discharged

overboard at a rate and configuration suitable to maintain ocean temperatures at or below permitted levels.

2.7.5.2. Process Heating

A process heating system is required as part of the crude oil treatment process to achieve the required crude oil specifications. A closed-loop, water-based heating medium system will be used to add heat to the incoming production stream. Waste heat from the power generation system will be used as the source of heat.

2.7.5.3. Flaring System

The FPSO has been designed to re-inject associated gas under routine conditions, except that which will be used as fuel gas, flare pilot gas, and background flare gas (e.g., purge, compressor seals) for FPSO operations and other *de minimis* sources not captured by the VRU. A flare system will be provided for the collection and safe disposition of hydrocarbon gases resulting from non-routine relief, blowdown, and maintenance events. Relief events occur to prevent overpressure scenarios in the process equipment. Blowdown events occur to depressurize the facilities in a controlled manner as a result of emergency shutdown events. In addition, temporary, non-routine flaring will occur during equipment maintenance, process upsets and during commissioning and start-up. The flare system will include both an HP and LP flare sharing a common flare tower. The flare tower has elevated flare tips for both HP and LP flares, which provide for the safe ignition of hydrocarbon gases. Both flares will support high-efficiency combustion and will use pilots that have minimal emissions. The estimated flaring volumes from FPSO commissioning and start-up through the end of the production operations stage are presented in Table 2.7-2.

Estimated flaring volumes are provided for two cases designated as the “Design Case” and “Modeled Case.” The Design Case emissions are based on estimated annual flaring, including an estimate of non-routine flaring in accordance with design basis assumptions for the Project. The Modeled Case emissions include an additional contingency for non-routine flaring volumes and are considered to reflect a credible worst case for non-routine flaring. Operational reliability performance is best described as a range of experience. Recognizing that range, a “low side” and “high side” estimation has been included to demonstrate the potential range for experience.

Table 2.7-2: Estimated Flaring Volumes during Yellowtail Commissioning, Start-up, and Production Operations Stages

	Design Case	Modeled Case
Production Operations Year	**Estimated FPSO Total Flaring Volumes (MMscf/year) [a]**	**Estimated FPSO Total Flaring Volumes (MMscf/year) [a]**
2025	3,751	3,782
2026	13,993	14,358
2027	3,584	6,632
2028	4,154	7,676
2029	4,570	8,439

	Design Case	Modeled Case
2030	5,128	9,463
2031	5,172	9,543
2032	5,205	9,603
2033	5,216	9,623
2034	5,117	9,443
2035	5,084	9,382
2036	4,307	7,957
2037	4,876	9,001
2038	3,738	6,913
2039	4,066	7,515
2040	3,650	6,753
2041	3,749	6,933
2042	2,588	4,805
2043	2,927	5,428
2044	2,807	5,207

MMscf = million standard cubic feet

[a] Estimated annual flaring volumes represent flaring associated with start-up and commissioning activities beginning in late 2025 and extending into 2026. If start-up and commissioning are delayed, the distribution of flaring volumes may change (e.g., a decrease to the flaring in 2025 and an increase to the flaring in 2026).

Estimated flaring is higher in 2026 due to start-up. Start-up operations on the FPSO include temporary flaring, which is standard within the industry until the gas compression and re-injection system are fully commissioned. Commissioning shall be defined as the process of ensuring that all new, modified, renovated, or upgraded systems and components are designed, installed, and function-tested, according to the operational requirements and manufacturer's guidance and/or Company and Operator best practices, as applicable. Commissioning of these systems will require hydrocarbon introduction, which will result in flaring until all associated function-testing activities are completed and systems performance tests are accepted. A significant amount of equipment must be successfully commissioned in a defined sequence prior to gas re-injection. Each step of the process requires a defined amount of steady natural gas supply to fully commission, test, and optimize the system. During the commissioning period, critical reservoir data are captured, maximizing long-term value of the resource. Following the initial start-up period, flaring (beyond flaring of pilot gas, purge gas, and other *de minimis* streams described in this chapter) will take place when necessitated by shutdowns, upsets and emergency conditions, planned or unplanned maintenance, production re-starts following shutdowns, and potentially commissioning and start-up of new units or renovation of existing units. A safety pilot flare will always be lit on the FPSO to maintain the flare in a safe and reliable state.

The estimates provided in the EIA are preliminary and intended to be conservative for use in worst-case emission estimates and air dispersion modeling. Flaring volumes associated with start-up will be further refined based on schedule optimizations to achieve pilot flare as early as feasibly possible. Across its operations, ExxonMobil has systems in place to improve operations integrity, thus reducing downtime and unexpected events that can result in temporary flaring.

There are three main ways in which flaring will be reduced during steady-state operations: maintenance programs, operational procedures, and monitoring. Implementation of proactive and preventative maintenance and testing programs will reduce flaring by minimizing downtime from equipment failure and will facilitate continuous maximum flare efficiency. Additionally, Operations will follow specific developed procedures for starting up and shutting down equipment. The facility will be monitored on a 24-hour per day basis to manage operational events that may cause flaring. This monitoring will provide the capability to intercept and deflect events that may result in flaring to the extent possible. Finally, lessons learned from commissioning, start-up, and operation of other FPSOs in Guyana will be reviewed and appropriate mitigations put in place to avoid recurrence of issues found in the past. For example, as described above, the Flash Gas Compression, Main Gas Compression, and Gas Re-injection systems will be equipped with spare compression capacity to reduce non-routine flaring duration.

With respect to start-up, the Project is targeting 60 cumulative days for start-up flaring, recognizing that this would represent industry-leading performance. For the purpose of this EIA, the estimated emissions are based on the conservative assumption that start-up flaring for the Project will be temporary and may require flaring for 90 cumulative days at the rate of 120 million standard cubic feet per day (MMscfd). In the United States offshore, flaring may occur for up to 1 year with regulatory approval (30 Code of Federal Regulation [CFR] §250.1161): “[An operator] must request and receive approval from the Regional Supervisor to flare or vent gas for an extended period of time. The Regional Supervisor will specify the approved period of time, which will not exceed 1 year.”

2.7.5.4. Topsides and Subsea Chemical Injection

The FPSO will have storage and injection facilities to inject the required amounts of chemicals and methanol into the production fluids to support production operations, both for subsea chemical injection requirements and for topsides chemical injection requirements.

Topsides chemicals may include corrosion inhibitors, scale inhibitors, asphaltene inhibitors, emulsion breakers, anti-foam agents, demulsifiers, oxygen scavengers, biocides, water-treatment chemicals, hydrogen sulfide (H_2S) scavengers, and specialty chemicals such as dispersants. Subsea chemicals may include methanol, scale inhibitor, corrosion inhibitor, asphaltene inhibitor, pour point depressant, H_2S scavengers, wax inhibitors, xylene, and specialty chemicals such as asphaltene solvents. Methanol and xylene will be stored in tanks that are integrated into one of the FPSO hull cargo tanks. For other chemicals that require large storage volumes, storage in the hull may be necessary.

2.7.5.5. Air

An air compression system will be provided to supply hull and topsides equipment. Compressed air is required primarily for the operation of control valves and other process instrumentation requirements.

2.7.5.6. Nitrogen

Instrument air will feed the nitrogen generation system. Nitrogen will be provided as required for purging, inerting, and blanketing, and as required for miscellaneous utilities.

2.7.5.7. Drains

The topsides will be equipped with the following drain systems:

- Nonhazardous drain system: used to collect drain fluids (e.g., rainwater) from non-hydrocarbon areas and to route them either to the slop tank in the FPSO hull or directly overboard in case of excessive drain rates;
- Hazardous drain system: used to collect drain fluids (e.g., oil-contaminated water) from hydrocarbon areas and to route them to the slop tank in the FPSO hull; and
- Closed drain system: used to collect drain fluids from produced water systems and to route them back into the process.

2.7.5.8. Other Utility Systems

A minimum of two deck cranes will be provided for supply boat offloading and materials handling and to support general maintenance activities. Workshops, a laboratory capable of checking the properties of the produced and injection fluids as well as select discharges for compliance, a medical facility, and a storage facility for supplies and spare parts will also be provided. Heating, ventilation, and air conditioning systems will be provided for buildings and enclosures.

2.7.6. Power Generation System

The required power for the FPSO will be generated by three systems:

- The main power generation system will be gas turbine-driven generator sets with spares available in the case of unplanned downtime. All generator sets will be dual-fuel (diesel and fuel gas).
- The essential services power generation system will be a diesel-driven generator set. Essential services include systems required for facility restart and for flow assurance hydrate mitigation activities after an unplanned shutdown.
- The vessel emergency power generator set will be diesel-driven and will provide power to both the hull and topsides emergency systems (e.g., safety systems including emergency lighting, telecommunication, etc.).

Additionally, for backup power during emergency situations, an uninterruptible power-supply system will be provided to power equipment such as the Integrated Control and Safety System (ICSS), subsea controls, etc.

2.7.7. Fuel Storage and Bunkering

Fuel to support FPSO operation will be stored in FPSO hull tanks, and systems will be provided to supply fuel to both hull and topsides users. The vessel's marine gas oil (MGO)[19] system has the capability to bunker, store, purify, recirculate, and transfer MGO to MGO users. MGO is used in the essential generators, emergency generator, utility station, topsides gas turbine generators/compressors, and diesel-hydraulic driven firewater pumps. A minimum of 8.5 days of fuel storage is available for normal production and offloading in the event that fuel is not available. MGO or marine diesel oil is stored in the FPSO cargo oil tanks. The MGO system, simplified in Figure 2.7-15, includes transfer pumps, purifiers, and filters.

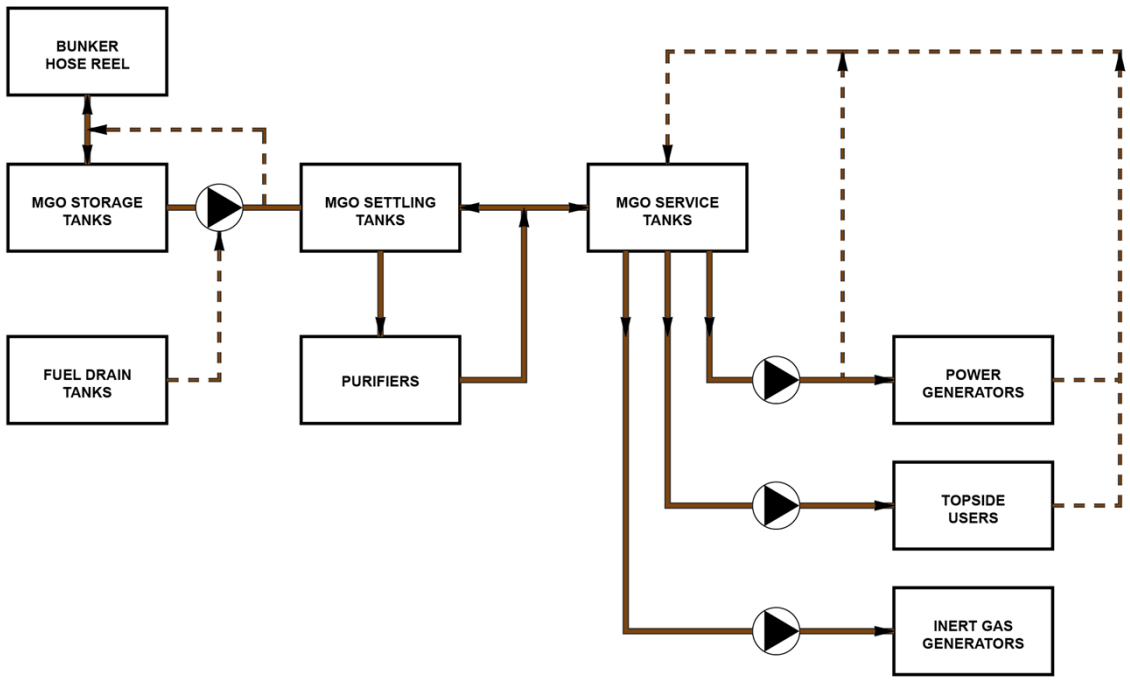


Figure 2.7-15: MGO System Schematic

MGO is bunkered into MGO storage tanks using a bunkering station located at the starboard side of the FPSO. While the principal transfer route for MGO is from a supply boat via the bunkering station to the MGO storage tanks, the MGO system is arranged such that unloading to a supply vessel, via the bunkering station, can be carried out from any of the following:

- MGO Storage Tanks
- MGO Settling Tanks
- MGO Service Tanks
- Fuel Overflow Tank
- Fuel Drain Tank

[19] While the technical designation for the system is the "Marine Gas Oil" (MGO) system, the system will manage marine diesel fuel used by the FPSO.

2.7.8. Integrated Control and Safety System

Monitoring and control of the FPSO production operations will be performed by an ICSS. Located in the main control room of the FPSO, the ICSS will include process shutdown, emergency shutdown, and fire and gas systems to protect the facilities and personnel. These systems will interface with a public address and general alarm system to provide distinct audible and visual alarm notification. The ICSS includes the following subsystems:

- PCS: the PCS will perform primary process control, monitoring, and data acquisition functions.
- Safety Instrumented System (SIS): the SIS will implement functions for abandoning the host facility, emergency shutdown, fire and gas detection, and process shutdown. Also included in the SIS will be a shutdown function for the subsea control / safety system. The SIS will provide detection, logic sequencing, and actuation of devices to place the facility in a safe state.
- Fire and Gas System.
- Alarm Management System.
- Operator graphics/consoles.
- Third-party interfaces to packaged systems (such as compressors, subsea, marine, etc.).

2.7.9. Communication Systems

Telecommunications equipment will be installed on the FPSO to enable safe operation of the facilities in normal and emergency conditions. This equipment will allow communication with the shorebases, support vessels, helicopters, and tankers, as well as communication within the FPSO. EEPGL has recently received approval for the Fiber Optic Cable Project, which will install fiber optic communication infrastructure from the Stabroek Block to shore, enabling high-speed, low-latency communications and data transfer between EEPGL's FPSOs and shore. The approved Fiber Optic Cable Project includes installation of subsea infrastructure, including optical distribution units (ODUs), located south of the Liza Phase 1 and Liza Phase 2 FPSOs, and connection of the Liza Phase 1, Liza Phase 2, and Payara FPSOs to the ODUs. As part of a future application for environmental authorization, EEPGL will propose to connect one of the ODUs to a Yellowtail drill center.

2.7.10. Additional Vessel Systems

2.7.10.1. FPSO Cargo Systems

The main purpose of the FPSO cargo system will be as follows:

- To receive, distribute, and store on-specification crude oil from the process facilities into designated FPSO cargo tanks;
- To receive and store off-specification crude oil from the process facilities into a designated FPSO cargo tank; and

- To offload the crude oil stored in the FPSO cargo tanks into a conventional tanker at regular intervals.

The slop tank discussed in Section 2.7.4.7, Slop Water System, will receive discharge from the topsides nonhazardous and hazardous drain systems as well as stripping water from the FPSO cargo tanks. Each FPSO cargo oil tank is fitted with a stripping eductor. Cargo tank stripping up to a level of 100 millimeters (4 inches) can be achieved via crude oil pumps. If further stripping is required, the stripping eductors will be used. Water from the slop tanks is used to drive the stripping eductor, the purpose of which is to strip the FPSO cargo tanks to a level below 100 millimeters (4 inches)—to prepare the FPSO cargo tank for entry. This water is referred to as stripping water. The oil-water mixture from the bottom of the FPSO cargo tank is routed back to the slop tanks. The oil and water in the slop tank will be gravity-separated by a minimum residence and retention time. Once separated, the oil will be skimmed off the top and sent to the cargo tanks and the water will be discharged overboard to residual oil-in-water discharge specifications. The slop system is capable of treating the slop water (heat-assisted, two-stage, gravitational separation). The oil content in the slop tank will be continually monitored with a dedicated meter such that the overboard discharge will not contain more than 15 ppm oil.

The FPSO cargo tanks are normally blanketed with hydrocarbon gas that is supplied from the fuel gas system. When the tanks are being loaded, hydrocarbon gas is displaced and routed to the Flash Gas Compression system. When the cargo tanks are offloaded, low-pressure fuel gas is used to blanket the tank. The inert gas generator is only used to blanket the tanks if the fuel gas system is offline or prior to tank entry. When the tank is blanketed with inert gas, any vapor discharge is routed to cold vents stacks located at a safe height at the bow of the FPSO.

The marine cargo system supports the following routine activities:

- Flushing of the crude oil offloading export hose;
- Emergency and temporary ballasting of FPSO cargo tanks with seawater; and
- Inspection and maintenance of FPSO cargo tanks and piping systems between offloading operations.

2.7.10.2. Crude Oil Offloading

Export of the crude oil from the FPSO will be via a floating hose connected to the manifold of a conventional third-party tanker. The FPSO will be configured for tandem offloading to a conventional tanker. The separation distance between the stern of the FPSO and the conventional tanker will be approximately 120 meters (390 feet). The maximum conventional tanker classification envisioned is a Very Large Crude Carrier class. During offloading operations, the conventional tanker will maneuver and hold station relative to the FPSO with the assistance of up to three assistance tugs, as shown on Figure 2.7-16. Crude oil will be transported per the buyers' instructions by the conventional tankers after each offloading operation.

Figure 2.7-16: General Offloading Configuration

2.7.10.3. Ballast System

Ballast water will be required during the FPSO transit from the shipyard to offshore Guyana. Once on site, the un-needed ballast water from the FPSO may be discharged overboard in accordance with IMO requirements.

2.7.10.4. Spread Mooring System

The FPSO will be permanently moored by fixed spread mooring with an up to 22-point mooring line system, with each line connected to its respective anchor pile embedded into the seafloor. The anchor piles will be either suction piles or driven piles. The mooring system will be designed to maintain the FPSO on-station for a 100-year environmental condition.

2.7.11. Safety and Personnel Protection Systems

Safety systems will include the following:

- Firewater System—The firewater system will have pumps located at the fore and aft ends of the FPSO.
- Fire and Gas Detection Systems—Fire and smoke detectors will be located throughout the topsides and living quarters and will be wired centrally with alarms sounding in the CCR, which will activate the general alarm system on the FPSO. Gas detectors will be placed in areas where gas might be released or could accumulate.
- Blanket Gas Generation—To prevent fires, the cargo tanks are blanketed with hydrocarbon gas that is supplied from the fuel gas system. The inert gas generator is used to blanket the tanks if the fuel gas system is offline or prior to tank entry. Other spaces, including the

methanol and xylene tanks, will be blanketed by nitrogen, which is produced by routing compressed air through the nitrogen membrane package.

- Lifeboats and Life Rafts—The FPSO will be provided with free fall lifeboats on the stern of the vessel, having a capacity for 100 percent of the personnel on board. A fast rescue boat will also be provided, complete with a davit launching and retrieving system.

2.8. INSTALLATION, HOOK-UP, AND COMMISSIONING

Final design of the installation, hook-up, and commissioning activities for the SURF, FPSO, and associated moorings has not been completed; however, key installation, hook-up, and commissioning activities will include the following:

- FPSO Mooring Installation—Installation of the FPSO's anchor piles and mooring lines. Following installation, the mooring lines will be staged on the seafloor until arrival of the FPSO.
- Flowline/Riser Installation—Installation of the production, water injection, and gas re-injection flowlines and risers. These components will be cleaned and hydrotested to verify integrity after installation. Some components may be staged on the seafloor until arrival of the FPSO; others may be brought in and installed with the FPSO.
- FPSO Positioning and Mooring Connection—Positioning of the FPSO using support tugs, followed by retrieval of the FPSO mooring lines from the seafloor and hook-up of the FPSO to its mooring system.
- Manifold / Drill Center Components—Installation of the manifold foundation piles / mud mats and subsea components at the drill centers and testing to verify integrity after installation.
- Umbilical Installation—Installation of the umbilicals and SDU.
- Riser Connection—Retrieval from the seafloor, pull-in, and connection of the risers to the FPSO.
- Testing and Commissioning—Testing and commissioning of the connected, integrated FPSO and SURF production systems, including testing and dewatering/displacing flowlines and umbilicals with commissioning fluids and testing SURF control and shutdown systems.

The above activities will be executed in an optimal sequence with activities completed in parallel where possible.

During the installation stage, a remotely operated vehicle (ROV) may be periodically used underwater to support the above-mentioned activities (e.g., observations, connections, sampling, etc.). During testing and commissioning, the Project will leverage learnings from previous testing and commissioning campaigns in Guyana and other projects to minimize the probability of unplanned releases occurring.

2.9. START-UP

The initial production start-up (commonly referred to as “First Oil”) sequence will include gas turbine generators, utilities, oil systems, the Main Gas Compression system, the Flash Gas Compression system, the Re-injection Gas Compressor system, and seawater treatment and injection systems. The expected FPSO start-up sequence actions and a description of each action are included in Table 2.9-1. Final start-up plans will be developed closer to First Oil.

Table 2.9-1: Start-up Sequence

Start-up Action	Description
Satisfy the Completion of All Prerequisites	The following items will be addressed before commencing “First Oil” start-up activities: • Fire and Gas System to be fully commissioned and in service; • ICSS to be in service; • All minimum required fire-fighting equipment available; and • Personnel trained in use of fire-fighting systems, Fire and Gas System, ICSS, and process equipment.
Prepare and Commission Auxiliaries and Utilities	The following systems will be online before commencing First Oil start-up activities: • Power generation; • Instrument air; • Nitrogen generation; • Heating medium; • Cooling medium; • Chemical injection; • Flare system; • Drains system; • Cargo system, including slop tank; • Inert gas system; • Seawater treatment system, up to and including reverse osmosis unit (for wash water); and • Laboratory must be available to perform incoming fluid analyses.
Prepare Oil Train for Receiving Hydrocarbons	Before hydrocarbons are introduced to the FPSO and flushing of the risers can take place, the oil train needs to be prepared. Flushing liquids will be routed through the oil train. At this stage, the main preparation will comprise: • Valve line-up checks; • Verification that Process Safety System (PSS) and PCS instrumentation are online; • Filling vessels with water to normal operating levels; and • Oxygen-freeing the vessels using nitrogen and applying pressure by using nitrogen in the vessels such that fluid transfer through the separation stages is feasible. The cargo oil tanks and produced water tank will be prepared and lined up accordingly; a cargo oil tank will be nominated to take the flowline and riser fluids only. No completions fluids will be sent to the vessel tanks.
Line-up and Inert Process Vessels and Flare Systems	In preparation of routing live hydrocarbons into the FPSO facilities, the flare systems will be prepared by purging with nitrogen. This will be performed during the preparation of the oil train vessel filling. The process vessels and compression trains will be pressure cycled to the

Start-up Action	Description
	flare systems with nitrogen followed by continuous nitrogen purging of the flare headers at the dedicated points.
Leak-test Risers, Flowlines, and Umbilicals	Leak tests are required of the umbilical lines once all risers, including umbilicals, have been pulled in and prior to termination of the umbilicals to the Topside Umbilical Termination Unit plate taking place.
Prepare and Commission Pigging / Flushing System	Subsea flowlines and risers will be left full of fluids (inhibiting water after leak testing).
Flush Subsea Oil Flow Lines and Risers with MGO	Just prior to starting riser flushing, the oil processing topsides on the FPSO will be considered “Live.” The flare system will be prepared to receive gas from the oil train. This requires that the flare systems have been lined up and nitrogen purged, and a continuous nitrogen supply is applied into each flare header. The subsea well and jumper will have been prepared and treated with methanol to displace water into the manifold/flowline. The fluids in the subsea risers and flow loops will be displaced with MGO and returned to the test separator. This will prepare the subsea well, flowlines, and risers and establish normal operating “oil” levels in some of the oil separation vessels. A safety stand-down will be held to inform all personnel about the operations that are about to commence, and topsides will change to ‘Live’ status.
Condition Gas and Water Injection Risers / Flowlines	All water will be displaced from the risers and flowlines on completion of the leak test of the gas and water injection risers and flowlines by pushing a pig train containing a pill of fresh water followed by mono-ethylene glycol (MEG) driven by nitrogen to a temporary subsea pig receiver from a temporary launcher on Topsides. All water might be flushed out subsea based on commissioning strategy. The risers can be left pressurized with nitrogen on completion of the pigging operations. This will assist with the start-up of gas injection. The temporary launchers will be removed prior to pressurizing of the gas injection risers and flowlines with the gas from the injection compressors.
Start Up First Well	The first well will be brought online when the risers have been flushed with MGO and confirmed by EEPGL. Part of the start procedure will require the injection of methanol to prevent hydrate formation.
Start Up Oil Train	Well fluids will be routed through the Test Manifold to the Test Separator at the start-up of each well. The Test Separator will be operated in “HP mode” and fluids will be routed to the Crude-Crude Exchanger, Crude Oil Heater, IP Degasser, LP Separator, Crude Oil Pumps, Electrostatic Treater, Crude-Crude Exchanger, and Crude Oil Cooler. Completion fluids settled out in the Test Separator will be routed to the Produced Water Flash Vessel. Exchangers and turbine meters (where possible) will be bypassed during initial clean-up of the first well to prevent blockages where possible. The HP Flare can be ignited after a predetermined time of purging with hydrocarbon gas.
Start Up Main Gas Compression	As an adequate and stable flow of associated gas is achieved from the HP or Test Separator, the Main Gas Compression System may be started, and commissioning completed. It is anticipated that closed loop runs will be completed at the integration yard.
Start Up Fuel Gas and TEG System	Wet gas from the HP Separator, taken downstream of the performance scrubber, can be used for the power generation turbines during the start-up for a short period. Dry HP fuel gas will be available for Topsides power generation when the Main Gas Compression and gas

Start-up Action	Description
	treatment (TEG system) are available. This will require the TEG contractor off-gas to be within specification. The Inert Gas Generator change-over from liquid to LP fuel gas will be performed as soon as sufficient and stable LP fuel gas is available, to commission dual fuel capability; however, cargo tank blanketing will be from the fuel gas system for hydrocarbon blanketing.
Pressurize Gas Injection Riser	The plan is to maintain as much pressure as possible in the risers after dewatering operations to reduce the Joule-Thompson effect due to pressure drop creating low temperatures. This allows the compressors to be started without the requirement of pressurizing with HP fuel.
Start Up Export-Injection Gas Compression	Once the Main Gas Compression and gas treatment systems have been commissioned and brought online and on-spec treated gas is available, the Export-Injection Gas Compression system will be commissioned.
Start Up Flash Gas Compression Second and Third Stages	The Flash Gas Compressor Second and Third Stages can be started once a sufficient and stable gas supply from the Intermediate Pressure (IP) Degasser and Produced Water Flash vessel is available and the Main Gas Compression system is operational. Flash Gas Compressor Second and Third Stage discharge will be routed to the Main Gas Compression compressor suction header.
Start Up Flash Gas Compression First Stage	The Flash Gas Compressor First Stage can be started once a sufficient and stable gas supply from the LP Separator is available and the Main Gas Compression and Flash Gas Second and Third Stage are operational. The Flash Gas Compressor First Stage discharge will be routed to the Flash Gas Compressor Second Stage suction header.
Start up and Clean up Stand-alone Screens (SAS) and Open-hole Gravel Pack (OHGP) Wells	Sand jetting will be connected to the dedicated tie-in points for the Test Separator and flare systems prior to opening up and bringing on SAS and OHGP wells temporary online. Any remaining completions fluids in the test separator water compartment will be transferred to the produced water flash vessel and decanted to tote tanks from there.
Start Up Water Injection	The water injection pumps commissioning can be started once Seawater Treatment has been commissioned and the Sulfate Reduction Package is online and on spec. On completion of the water injection pump start-up and commissioning runs, the risers and flowlines can be displaced with water injection quality treated water directly into the reservoir.

2.10. ADDITIONAL ASPECTS OF PRODUCTION OPERATIONS

The various processing elements of production operations are discussed above. This section discusses other key aspects of the production operations for the FPSO.

2.10.1. Common Flow Assurance Additives

Some industry-standard chemicals will be required to process the produced oil on the FPSO. Both the FPSO and SURF facilities will also require the use of industry-standard additives to provide flow assurance and prevent corrosion, scale formation, hydrate formation, asphaltene formation, wax formation, and emulsification, as previously noted in Section 2.7.5.4, Topsides and Subsea Chemical Injection. The specific chemical requirements and quantities will be determined as part of the ongoing FPSO and SURF facilities design work. Particular attention

will be paid to scenarios that could result in flow instabilities, restrictions, or blockages, or which could jeopardize the integrity of the fluid-transfer systems or reduce overall system operability. The objective of the following sections is to provide a general overview of the flow assurance challenges and strategies.

2.10.2. Hydrogen Sulfide Management

The concentration of H_2S will be extremely low for the initial stage (i.e., 1 to 5 years) of FPSO/SURF production operations. There may be potential for the reservoir to sour[20] over time, which influences material selection and corrosion inhibition for certain FPSO, SURF, and drilling systems. In the unlikely event that concentrations of H_2S increase to a level that could represent potential health or safety concerns for the Project's offshore workforce, additional management measures will be implemented as appropriate (e.g., training programs [initial and annual refresher], personal protective equipment (PPE), response planning, and equipment for leak detection and alarms). Examples of such measures will include installation of an H_2S gas detection system (as required based on actual reservoir souring) and a double block-and-bleed isolation in areas where process fluids may have higher H_2S levels.

2.10.3. Marine Safety

The Maritime Administration Department (MARAD) of the Ministry of Public Infrastructure is responsible for issuing notices to mariners concerning safety at sea. MARAD will be advised of the locations of drill ships during the drilling of the development wells and the performance of well workovers in the PDA so that mariners can be made aware of these activities. As shown on Figure 2.10-1, marine safety exclusion zones with a 500-meter (1,640-foot) radius will be established around drill ships during drilling operations and around drill centers during well workovers, as well as around major installation vessels, in accordance with good international oilfield practice (IMO 1989).

Authorizations for major in-water activities will be obtained from MARAD and notices to mariners will be issued for all marine vessels, including the FPSO, supply and support vessels, tugs, and those vessels to be used during the installation, hook-up, and commissioning stage.

As shown on Figure 2.10-1, the FPSO will have a 2-nautical mile-radius (2.7-kilometer-radius) marine safety exclusion zone centered on the FPSO during offloading activities, where marine support and tanker offloading will occur. No unauthorized vessels will be allowed to enter this approximately 4,310-hectare (10,650-acre) operational marine safety exclusion zone during offloading activities.

[20] A reservoir "souring" means the levels of sulfur in the recovered crude oil increases over time relative to levels at the initial stages of recovery.

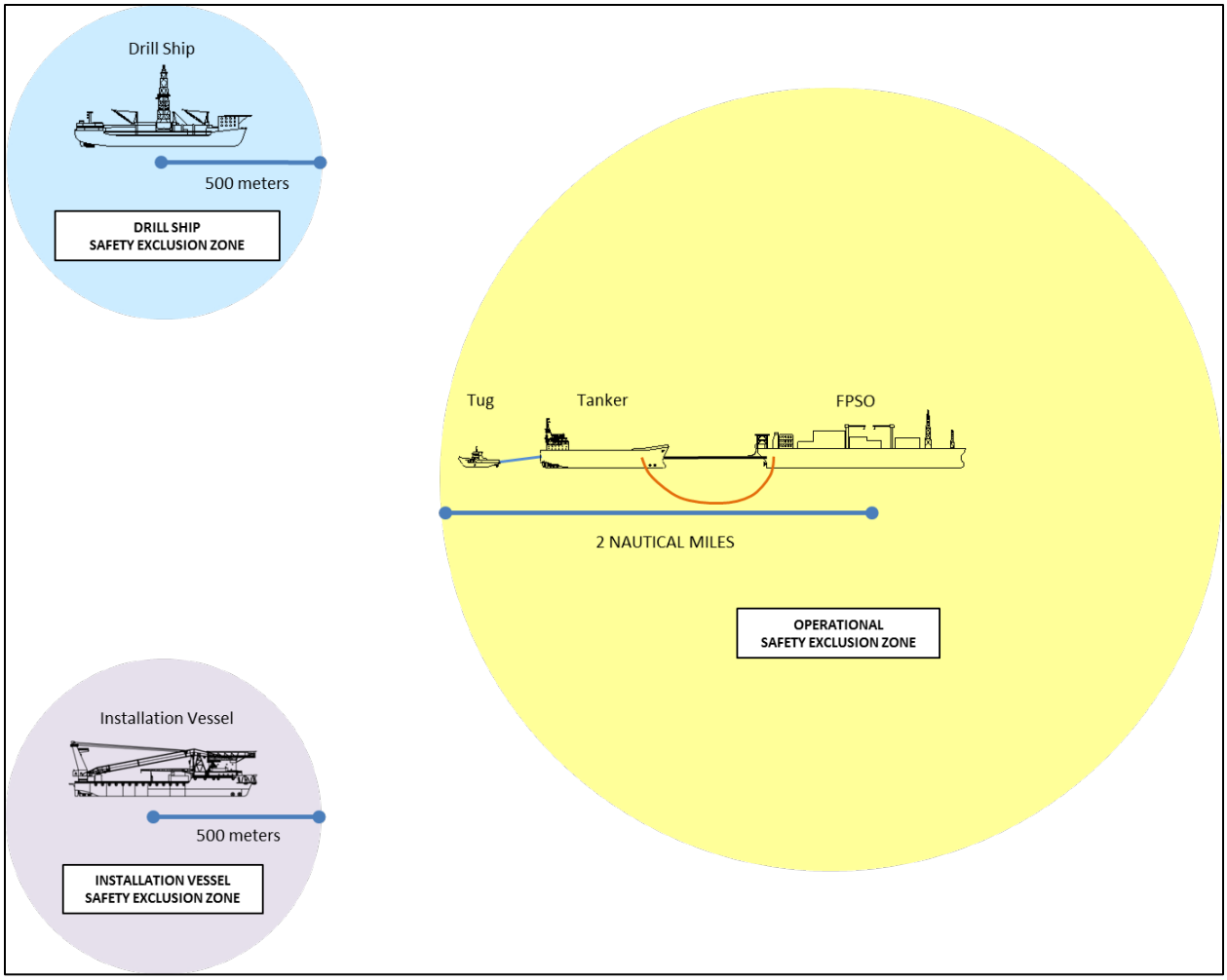


Figure 2.10-1: Preliminary Marine Safety Exclusion Zones

2.10.4. Offloading Tankers

Conventional tankers supporting offloading operations will typically arrive anywhere from 1 day to several hours ahead of the scheduled loading time, as a function of weather and ocean conditions. To accommodate these vessels, an anchorage area will be established several kilometers away from the FPSO. When the tanker is ready to approach, a Mooring Master will board the conventional tanker approximately 2 kilometers (1.2 miles) from the FPSO to guide the conventional tanker to the FPSO and to support the offloading operation. The conventional tankers will export the crude oil for sale after offloading operations have been completed. Conventional tankers will be owned/operated by others and will not be dedicated to the Project.

The following is a summary of the tanker activities anticipated as a result of the Project, as well as the operational procedures and controls (maritime navigation protocols, safety procedures, communication protocols, etc.) that will be implemented in relation to these activities, including tanker transit within Guyana waters and during offloading of oil from the FPSO to the tankers on the Stabroek Block. Although outside the scope of the EIA, the information below also includes a conceptual description of the key marine and terminal operational procedures and safety

controls that will be used during international transit outside of Guyana waters. The discussion is presented for two phases: pre-cargo (activities up to the point where crude oil is offloaded from the FPSO to the offloading tanker) and post-cargo (activities from the completion of offloading at the FPSO up to the offloading of the crude oil at the delivery port).

2.10.4.1. Pre-Cargo Phase

The Pre-Cargo Phase covers the offloading tanker from the time of Nomination by Lifter[21] through the start of cargo operations at the FPSO. This includes ocean transit to the tanker waiting area, final approach to the offloading station, mooring operations, and activities to prepare for the commencement of offloading operations. The operations and controls for this phase include the following:

- Ocean transit to waiting area: The offloading tanker will be under the control of the Vessel Master, governed by international and flag-state regulation and owner/operator policies.
- Final approach to station[22] and mooring operation: The offloading tanker will be under the control of the Vessel Master, assisted by the Mooring Master from the FPSO. The Mooring Master acts as the FPSO representative and advisor and will be located onboard the offloading tanker. The Mooring Master is tasked with coordinating and directing the offloading tanker's approach, communications with assist tugs and the FPSO, and mooring operations between the offloading tanker and the FPSO. The Vessel Master is ultimately responsible for safety, security, regulation, and owner/operator policy enforcement as relates to the operations of the offloading tanker.
- Activities to prepare for the commencement of cargo operations: The offloading tanker will be under the control of the Vessel Master, assisted by the Mooring Master from the FPSO. The Mooring Master may assist with communications and enforcement of FPSO procedures onboard the offloading tanker. The Vessel Master is ultimately responsible for safety, security, regulation, and owner/operator policy enforcement as relates to the operations of the offloading tanker.

2.10.4.2. Post-Cargo Phase

The Post-Cargo Phase covers the offloading tanker from the completion of offloading of crude oil from the FPSO through the eventual discharge of the loaded cargo at the delivery port. This includes completion of cargo documentation, pre-departure safety checks, unmooring, departure from station, ocean transit to the discharge port, and discharge of loaded cargo. The operations and controls for this phase include the following:

- Completion of cargo documentation and pre-departure safety checks: The offloading tanker will be under the control of its Vessel Master, who is responsible for the safety, security, and regulation/company policy enforcement as relates to operations of the offloading tanker.

[21] The "Lifter" is the party that is obligated to offload from the FPSO on certain dates based on the designated schedule. "Nomination" is when the Lifter provides the name and details of the planned offloading vessel to EEPGL. This is anticipated to be no later than 10 days prior to the lifting window.
[22] "Station" is the point where the offloading tanker is located when the offloading of crude oil takes place.

- Unmooring and departure from station: The offloading tanker will be under the control of its Vessel Master, assisted by the Mooring Master from the FPSO. The Mooring Master is tasked with coordinating and directing the unmooring operations, and communications with assist tugs and FPSO. The Vessel Master is ultimately responsible for safety, security, and regulation/company policy enforcement as relates to operations of the offloading tanker.
- Ocean transit to discharge port and discharge of loaded cargo (outside the scope of the EIA): The offloading tanker will be under the control of its Vessel Master, governed by international and flag state regulation and company policies.

2.10.4.3. Governance and Industry Standards

A number of protocols and procedures will be followed in relation to tanker activities in Guyana waters, and outside of Guyana waters (i.e., in transit to the international delivery port). These include the following:

- Safety of Life at Sea (SOLAS) Convention: Specifies minimum standards for the construction, equipment, and operation of ships, focused on safety standards. Key topics in SOLAS include Safety of Navigation (Chapter V) and Management for the Safe Operation of Ships–ISM Code (Chapter XI-2), among others.
- IMO International Convention for the Prevention of Pollution from Ships, as modified by the Protocol of 1978 (MARPOL 73/78): Developed by the IMO; includes international standards for seafarer training, regulations on mandatory traffic separation schemes, and requirements for segregated ballast tanks and double hulls for tankers, among other standards.
- International Safety Guide for Oil Tankers and Terminals: An industry-wide accepted guide for the safe carriage and handling of crude oil on tankers and at terminals; recommended to be kept and used onboard every tanker and in every terminal so there is a consistent approach to operational procedures and shared responsibilities for operations at the ship/shore interface; covers General Information (properties, hazards of petroleum, hazards for ship and terminal, etc.), Tanker Information (shipboard systems, equipment and operations, carriage and storage of hazardous materials, etc.), Terminal Information (terminal systems and equipment, cargo transfer equipment, emergency preparedness, etc.), and Management of the Tanker and Terminal Interface (communications, mooring, precautions on ship and terminal during cargo operations, etc.).
- Oil Companies International Marine Forum (OCIMF): Developed under a voluntary association of oil companies having an interest in the shipment and terminaling of crude oil, oil products, petrochemicals and gas; objective is to develop and publish guidance, recommendations and best practice by harnessing the skills and experience of OCIMF members and the wider industry; the OCIMF consults with IMO to influence and create internationally-accepted regulations aimed at improving the safety of tankers and protecting the environment.

2.11. ONSHORE, MARINE, AND AVIATION SUPPORT

2.11.1. Onshore Supply and Support Activities

The Project will require the use of onshore storage facilities and laydown areas in Guyana for Project materials (e.g., drilling fluid, pipe joints) and may also use onshore facilities in Guyana for pre-fabrication or assembly of Project equipment. At this time, EEPGL plans to use existing Guyana shorebases to support the Project; new onshore facilities in Guyana may also be used by the Project (these would be developed by third parties as separate projects). Similarly, EEPGL is planning to use existing third-party EPA-permitted waste management facilities in Guyana; additional Guyanese or regional waste management services may also be used in the future (these would also be developed by third parties as separate projects). All onshore support facilities that will be used by the Project will be owned/operated by third parties.

Should any new or expanded shorebases or onshore support facilities be used, the construction/expansion of such facilities, as well as the associated environmental authorizations, would be the responsibility of the owner/operator and such work scope is therefore not included in the scope of the EIA for the Project.

A typical shorebase quay is shown on Figure 2.11-1, and a typical laydown yard is shown on Figure 2.11-2. Additional logistical support may be provided by other regional suppliers outside of Guyana, as informed by inputs from EEPGL contractors after contract award, to address Project needs (e.g., deepwater port access in Trinidad).

Figure 2.11-1: Typical Shorebase Quay

Figure 2.11-2: Typical Laydown Yard

Onshore facilities will include pier/port/quayside space with sufficient draft for receipt of cargo vessels bringing materials to and from the shorebase; marine support vessels will be used to service the offshore activities and operations. A marine berth and secure warehousing space for indoor and outdoor storage of materials and goods, trucking, stevedoring, freight forwarding, customs logistics, receiving, inspection, and associated container handling and storage operations will also be used.

Daily activities and operations to be performed at the shorebases will generally include the following:

- Storage of pipe, equipment, and spares;
- Loading and unloading cargo from trucks and marine vessels;
- Use of cranes and other lifting equipment;
- Pre-fabrication and assembly of SURF and FPSO components;
- Bulk storage of chemicals, fuels, and industrial consumables;
- Operation of cement and drilling fluids and mud plants to support offshore drilling operations; and
- Secure handling, storage, and treatment of wastes pending final recycling, treatment, or disposal.

Most of the major SURF and FPSO equipment for the Project will be preassembled, pretested, and shipped directly to the Yellowtail PDA from points of origin outside Guyana, although some will be pre-assembled in-country. Some equipment, supplies, and materials may be temporarily staged at shorebases, laydown yards, and warehouses until transferred offshore for installation or use by the Project. There are plans for development of a new third-party operated SURF shorebase facility in Georgetown, at which SURF equipment for EEPGL's development projects could be assembled prior to transfer offshore for installation. Depending on the schedule for its completion, this new facility may be used by the Project, by other EEPGL projects, or by other oil and gas operators in Guyana. The owners/operator(s) of these facilities will be responsible for obtaining any needed environmental authorizations for any changes to current operations.

Support and supply vessels will require sufficient water depths to transit between the Yellowtail PDA and the shorebases. Accordingly, there is potential for some initial and periodic maintenance dredging to be performed by the owners/operator(s) of shorebases that will be used by the Project. Any such dredging will be subject to receipt of environmental authorization by the owners/operator(s) of the shorebases.

2.11.2. Logistical Support

Logistical support will be optimized and shared among Liza Phase 1, Liza Phase 2, Payara, and Yellowtail, as well as exploration drilling operations. It is estimated that during combined development drilling and FPSO/SURF installation, helicopter flights for the Project will be on the order of approximately 20 to 25 round-trip flights per week (assuming up to three drill ships drilling Yellowtail development wells concurrently). This same frequency of helicopter flights will continue during combined production operations and continued development-drilling activities (assuming up to three drill ships drilling Yellowtail development wells concurrently). Following completion of development well drilling, helicopter trips will reduce to an estimated five to seven round-trip flights per week during production operations. Helicopter usage will be optimized for all offshore activities for the Liza Phase 1, Liza Phase 2, Payara, and Yellowtail Development Projects as well as exploration drilling. Helicopters are currently, and will continue to be, flown out of Ogle Airport and routed directly offshore, avoiding flight paths over sensitive onshore areas such as schools and medical facilities.

Based on current drilling activities and past experience with similar developments, it is estimated that the Project will generate a variety of marine support vessel trips throughout the Project life. Support vessel activities will consist of the following (see Figure 2.11-3):

- Multi-purpose vessels supporting subsea installation and maintenance activities;
- Multiple supply vessels conducting re-supply trips to the drill ships;
- Multiple supply vessels conducting re-supply trips to the FPSO during operations;
- Vessels conducting vessel-to-vessel fuel bunkering;
- Tug vessels supporting tanker offloading activities; and
- Multi-purpose vessels supporting decommissioning activities.

Figure 2.11-3: Typical Logistics Support Vessels

The following vessel trips to or from a Guyana or Trinidad and Tobago shorebase are estimated based on past and ongoing exploration, development drilling activities, SURF installation activities for previously approved development projects, and more than 18 months of operating experience with the Liza Destiny FPSO:

- During development drilling (assuming three drill ships are supporting Yellowtail concurrently), support vessels could average approximately 18 to 21 trips per week to or from shorebases.
- During installation, support and installation vessels could average approximately three to five trips per week to or from shorebases.
- During the production operations stage, support vessels could average approximately three to five trips per week to or from shorebases.

2.11.3. Waste and Effluent Management

Waste and effluents generated offshore will be reduced, recycled, and treated offshore where practicable, with the remainder directed for onshore treatment, recycling, reuse, or disposal. The general types of EEPGL effluents that will be treated as needed and discharged offshore include:

- Non-aqueous fluid mud and drill cuttings;
- Water-based mud and drill cuttings;
- Various tank wash waters, slops, and other effluents that pass static sheen or other tests;
- Bilge water that has <15 ppm oil-in-water content;
- Produced water;
- Inert materials, including cement, barite, bentonite, calcium carbonate, gravel pack, sand, etc.;
- Food waste <25 millimeters (1 inch); and
- Treated sewage.

All of these discharges are subject to some type of pre-treatment and/or monitoring prior to discharge overboard in accordance with permit requirements, international conventions, relevant international standards, or good international oilfield practice (IMO 2003; IMO 2018). A small number of specific wastes are also treated offshore using thermal destruction technology. These include production well test fluids and certain other hydrocarbon-based wastes (such as oily sludges, engine oils, lube oils, etc.). Production well test fluids (reservoir fluids) are generated from a temporary production test performed to investigate how a newly drilled well will perform when it is subject to various flow conditions. The well test fluids are treated on the drill ships using a flare boom, which is a burner attached to a boom located downwind of the drill ship. Combustion may be initiated using diesel or similar fuel to ignite the mixture to promote complete combustion of well test fluids. However, only certain drill ships (e.g., *Stena Carron*) have the equipment required to perform well testing, including the fluid combustion. The use of a flare boom can last for several hours to several days and is usually intermittent during the well test. All well test flaring must meet the requirements of the permits. Other hydrocarbon-impacted wastes, including oily sludges, may also be treated offshore on vessels which are equipped with incinerator units. Any incinerator employed for use offshore must have an IMO-type approval certification consistent with IMO and MARPOL 73/78 requirements for shipboard incinerators.

For those wastes transported onshore, there are a limited number of facilities for the treatment of hazardous and industrial waste in Guyana, although the construction and proposal of additional such facilities are growing commensurate with the planned expansion of oil and gas activities. The Haags Bosch Landfill (HBL) is government-owned and is operated by a third-party contractor. The HBL is the only engineered sanitary landfill in Guyana, and started operations in early 2011. The HBL is the current destination for most municipal and commercial solid non-hazardous waste generated from the greater Georgetown area, including wastes generated from the 25-plus Neighborhood Democratic Councils between Mahaica, the Seawall, Timehri, and Parika. All non-hazardous solid wastes generated to date from EEPGL's projects have been disposed at the HBL. The original disposal cell (Cell 1) is at 99 percent capacity, and

Cell 2 started operations in late March 2021. At current disposal rates, Cell 2 will have approximately 4 to 6 years of disposal capacity. There remains space for additional cell(s) at the HBL location to be developed in the future.

Tiger Rentals Guyana Inc. (TRG), located at the Guyana Shorebase Inc. (GYSBI) facility, is currently the primary provider of hazardous and non-hazardous waste treatment services in Guyana. TRG employs a variety of waste treatment technologies (sorting/segregation of recyclables, physical/chemical/thermal treatment of hazardous and non-hazardous wastes), discharges its treated fluids as permitted to the Demerara River, and sends its treated non-hazardous solid waste as well as other wastes received (including general waste, paper/cardboard, and scrap wood) to the HBL. In addition to TRG, several additional private waste management facilities have come online or are expected to come online in the near-term for hazardous (and non-hazardous) waste treatment, including the following:

- Eternity Investment Inc. (EII) is a scrap metal consolidation and exporting facility that also accepts and manages lead acid batteries and electronic waste. EII is currently the only facility authorized by the EPA to manage electronic wastes. The main scrap yard for the facility is located in a sparsely developed area of Madewini near the Cheddi Jagan International Airport. The company receives non-ferrous (including lead acid batteries), ferrous, and electronic waste scrap, and then sorts and consolidates these materials. These materials are packaged in sea-going containers and exported to buyers worldwide. EII receives scrap metal from throughout Guyana.
- Sustainable Environmental Solutions Guyana, Inc. (SES) has constructed a new integrated waste management facility at GYSBI for managing wastes generated from offshore oil and gas operations; this facility went fully operational in 4Q2021. The facility employs various hazardous and non-hazardous waste management technologies, including hot oil thermal desorption, incineration, decanter/centrifuge separation, wastewater treatment, waste shredding, container crusher/baling, and container washing operations.
- Liquid Mud Plants (LMPs) (of which there are currently three) are operated by onshore drilling services providers that operate cement and drilling fluids facilities, including Schlumberger Guyana, Inc. / MI-Swaco (located at the GYSBI facility), Halliburton Guyana, Inc. (located at the G-Port facility at the mouth of the Demerara River), and Baker Hughes Guyana Inc. (also located at the G-Port facility). The LMPs manufacture drilling fluids (mud) for offshore oil and gas operations, but also receive spent mud from the offshore drilling operations for onshore reconditioning. The used muds are reclaimed using mechanical (centrifugation) and chemical processes, and the reconditioned muds are then returned to the drill ships for use in new drilling operations. The LMPs generate hazardous and non-hazardous wastes from their reconditioning operations, including fluids, cuttings, and other solids recovered from the used muds, as well as other operational wastes (e.g., wastewaters, oily rags, general refuse). Until recently, these wastes have been managed by TRG. In 3Q2021, the SES facility (see above) commissioned thermal desorption and incinerator operations and began receiving centrifuge solids from the LMPs. Commissioning of wastewater treatment operations at the SES facility is forecasted for 1Q2022.

- Oilfield Waste Management Services (OWMS) submitted a permit application to the EPA in 2020 for the construction of a 5,000 square meter (approximately 53,820 square foot) drilling waste processing plant in the Little Diamond East Bank Demerara area (located approximately 5 kilometers (approximately 3 miles) south of GYSBI). OWMS will employ thermal desorption separator (hammer mill) technology to treat drilling muds. Oil and water recovered from the process are proposed to be recycled in the formulation of new drilling muds, and the solids are proposed to be used in the bitumen manufacturing process or sent to the HBL. It is unknown when the OWMS plant will become operational.
- Environmental Waste Management Services Guyana Inc. submitted a permit application in late 2020 for the construction and operation of a waste treatment (bioremediation) facility for mud sludge generated from activities in the oil and gas sector. The proposed location of the facility is at Lots 21 and 22, Block XXV111 Zone Plantation Friendship, East Bank Demerara area. According to the EPA Public Notice issued in December 2020, the operation will involve the development of two treatment ponds lined with high-density polyethylene geomembrane liners and contained by 91.4-centimeter-high (approximately 36-inch-high) berms. The status of this application is not currently known, and it is also unknown when the facility would become operational.
- GYSBI currently operates a steel pipe warehouse, storage, and handling operation at its Annex location that involves the washing of virgin steel pipe prior to transfer to the wharf and loading onto the vessels for offshore transit. The non-hazardous wastewater from this washing operation is currently collected and treated in on-site evaporators, with no discharge of this wastewater. This location is being considered as part of a feasibility assessment for developing a new facility to exclusively manage used plastic drill pipe thread protectors that are generated from the pipe handling operations. Pipe thread protectors are designed to protect the critical threads of the steel pipes during storage, handling, and transport, and tens of thousands of these metal-reinforced plastic caps will be generated as a result of offshore well installation operations. These used plastic caps will first be subject to grinding to separate the plastic and metal parts, and the plastic will then be melted and pelletized and returned to the original manufacturer as a raw material for the production of new plastic caps. The recovered metal will also be recycled. Although being considered, it is uncertain when this type of facility would move forward at this location.

All wastes generated by the Project will be managed in accordance with a Comprehensive Waste Management Plan (CWMP) that will be used for the management of all EEPGL waste. The CWMP (Volume III of the regulatory submittal), which has been approved by the EPA, lists in detail the specific types of wastes that will be generated by the Project and their sources.

2.12. END OF YELLOWTAIL OPERATIONS (DECOMMISSIONING)

An affiliate-level Preliminary End of Operations Decommissioning Plan for Guyana Development Projects is included in Volume III of the regulatory submittal. The purpose of the Preliminary End of Operations Decommissioning Plan is to provide an overview of the proposed abandonment and decommissioning of development project wells and facilities at the end of their operations,

and to describe the anticipated work required to confirm that the abandoned facilities will be left in a condition that avoids harm to the environment.

Near the time of decommissioning, EEPGL will develop a more detailed decommissioning plan, in consultation with the appropriate Guyanese regulators. EEPGL will perform inspections, surveys, and testing to assess current conditions that will provide the basis and required information to prepare a more detailed plan for decommissioning. As part of that planning process, EEPGL will perform comparative assessments of decommissioning options for the various facilities components, as described in Annex A of *Offshore Oil and Gas Decommissioning Guidance Notes* (OPRED 2018). Where there may be multiple decommissioning options, including facility components left *in situ*, the assessments will assist in arriving at the final decommissioning recommendation.

The decommissioning plan and strategy will be based on a notice of intent for decommissioning the production facilities and plugging and abandonment of the development wells, which will be provided to the appropriate Guyana regulators, to obtain approval in accordance with the following requirements, and/or with future applicable legislation:

- Environmental Protection Act, Cap 20:05
- Petroleum Exploration and Production Act (1986)
- Petroleum Exploration and Production (Amendment) Act (1992)

As part of the decommissioning process, all risers, pipelines, umbilicals, and other subsea equipment will be safely and properly isolated, de-energized, and flushed to remove hydrocarbons and other hazardous materials to a suitable level prior to being taken out of service. It is currently envisioned that the risers, pipelines, umbilicals, and subsea equipment will be disconnected after flushing and preparation and left *in situ* on the seafloor at the production location, unless an alternative strategy is selected based on the results of the comparative assessments.

Development wells will be permanently plugged and abandoned (P&A). The objective of permanent well abandonment is to prevent escape of hydrocarbons to the environment. Well P&A is concerned with the isolation of rock formations that have flow potential and is achieved by restoring suitable cap rock via placement of P&A barriers. P&A barriers will be set adjacent to suitable cap rock and establish full lateral coverage (rock-to-rock) across the well bore and will be of adequate length to contain reservoir fluids and deep enough to resist being bypassed by reservoir pressure. The number of barriers required will depend on the distribution of hydrocarbon-bearing permeable zones within the wellbore. Barriers will be verified in a manner appropriate to the specific barrier. Verification may include tagging, positive or negative pressure testing, diagnostic logging, and/or review of the process that installed the barrier.

The FPSO will be disconnected from its mooring system, removed from the production location, and towed to a new location for reuse or decommissioning. The FPSO anchor piles and mooring lines are expected to be disconnected and abandoned in place on the seafloor at the production location, consistent with current good international oilfield practice, unless an alternative strategy is selected based on the results of the comparative assessment.

Waste streams associated with decommissioning activities, including hazardous and nonhazardous wastes, will be managed and disposed in accordance with applicable Guyana regulations, applicable international conventions and guidelines, and good international oilfield practice. Methods may include injection downhole into the reservoir, separation and incineration offshore for certain types of wastes, or transport to onshore waste management facilities for management and disposal for certain types of wastes.

2.13. MATERIALS, EMISSIONS, DISCHARGES, AND WASTES

This section describes the materials (i.e., primarily chemicals) that will be used across the various stages of the Project, as well as the Project's planned emissions, discharges, and wastes. Sound is not discussed specifically in this section. The Project will not generate any meaningful vibration that could impact resources/receptors. EEPGL will manage airborne sound through engineering controls, through administrative controls, and by providing appropriate PPE to its Project workforce as described in Section 6.2.3, Impact Assessment—Underwater Sound. Underwater sound is discussed in the marine mammals and marine turtles impact evaluations (see Sections 7.5.3 and 7.5.4 and Sections 7.7.3 and 7.7.4, respectively). The Project will generate thermal discharges to the environment, primarily in the form of heated effluent discharges to the sea; this is discussed as part of the marine water quality impact evaluation (see Sections 6.4.3 and 6.4.4). The Project will generate light, which is discussed as part of the seabirds and marine turtles impact evaluations (see Sections 7.4.3 and 7.4.4 and Sections 7.7.3 and 7.7.4, respectively). Naturally occurring radioactive material (NORM) that may be generated by the Project is addressed in Section 2.13.5, Radiation Emission Sources.

2.13.1. Materials Inventory

Offshore oil development is primarily an extractive process (e.g., producing oil from the reservoir). This extractive process will, however, require the use of various equipment described in this chapter (e.g., drill ships, pipes, flowlines, FPSO), as well as some chemicals used to facilitate well drilling, crude oil recovery, water/waste treatment, pipeline maintenance, and other purposes, which have been described in prior sections of this chapter. The required volumes of these chemicals are yet to be determined.

Table 2.13-1 below provides a preliminary list of the primary chemicals that will be used as part of the Project's drilling, installation/commissioning, and production operation stages. Table 2.13-2 provides estimates, where known at this time, of the quantities of materials that will be used during development well drilling (on a per-well basis). Tables 2.13-3 and 2.13-4 provide estimates, where known at this time, of the quantities of materials that will be used during the installation and production operations stages.

EEPGL is committed to chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. EEPGL's chemical selection process is aligned with applicable Guyanese laws and regulations and includes:

- Review of safety data sheets;
- Evaluation of alternate chemicals;

- Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including:
  - Using the minimum effective dose of required chemicals; and
  - Minimizing safety risk related to flammability and volatility;
- Risk evaluation of residual chemical releases into the environment.

EEPGL's chemical selection processes and principles will include, without limitation:

- Specifying in contracts that offshore chemical supply contractors shall protect the health and safety of people and the environment;
- Specifying that contractors shall perform services in compliance with applicable laws and EEPGL health and safety policies; and
- Working with established chemical suppliers.

Flow assurance chemicals are evaluated and selected based on a competitive technical and commercial evaluation bid process that includes various independent oilfield chemical supplier participants. Technical evaluations on oilfield chemical supplier proposed chemicals can include various tests and lab analyses to assess and evaluate chemical characteristics and performance against project-specified functional requirements, chemical performance specifications, and company- or country-specific criteria. Consistent with the above-referenced chemical selection process, a chemical's fate and potential effects on the environment will be considered during the evaluation and selection process. Additionally, all chemicals used for the Project will be registered with the Pesticides and Toxic Chemicals Control Board as required.

Types of flow assurance chemicals specified for the Project (such as but not limited to asphaltene inhibitor, scale inhibitor, xylene, methanol, etc.) are categories of industry standard chemicals that have been typically used within ExxonMobil and the oil and gas industry. As of the writing of this EIA, flow assurance chemicals for the Project have not been selected, but chemical suppliers in competition for the Project chemicals goods and services contract have previously provided similar chemicals for other oil and gas ventures. For example, the Liza Phase 1 Project has selected a similar chemical supplier that provides flow assurance chemicals such as asphaltene inhibitor, scale inhibitor, xylene, and methanol. Bulk chemicals such as methanol and xylene are industry standard chemicals used across oil and gas ventures. Although these chemicals are optimized, general chemical compositions and associated chemical information (e.g., safety data sheets) are provided to ExxonMobil for proper design, chemical management, and chemical handling purposes, as well as environmental standards.

Residual quantities of drilling and production chemicals may be discharged to the sea as components of drilling fluid or produced water, injected into the reservoir, or emitted to the atmosphere. Unused or used and recovered chemicals will be reused, recycled, or disposed of in accordance with applicable regulations and good international oilfield practice.

All chemicals will be stored—either at the shorebases, at contractor facilities, or on the drill ships or FPSO—in appropriate storage containers with either secondary containment or appropriate drainage control.

Table 2.13-1: Planned Project Materials and Chemicals

Project Phase	Primary Chemical Materials/Products	
Drilling	• WBDF • Inorganic salts • Barite • Water-soluble biopolymers and modified biopolymers • Thinners • Calcium carbonate • Lost circulation material [a] • Brines • Acids • Caustic soda • Surfactants • Hydrate inhibitor • Oxygen scavenger • Biocide • Soda ash • NADF with IOGP Group III NABF • Emulsifier • Non-emulsifier • Rheology modifier	• Wetting agent • Viscosity modifiers • Fluid loss modifiers • Lime • Corrosion inhibitor • Sand suspension additive • Cement class “G” • Extender • Defoamer • Retarder • Dye • Breaker • Silica flour • Lubricant • Alkalinity control agent • Fluids loss control agent • Filtration medium • Gas control agent • Diesel (as fuel to power drill ships, vessels, and equipment) • Proppant
SURF Equipment Commissioning	• Hydraulic fluid • Nitrogen • Hydrate inhibitor (e.g., methanol, ethylene glycol) • Marine gas oil (as fuel to power vessels and equipment) • Corrosion inhibitor	• Scale inhibitor • Asphaltene inhibitor • Xylene • Methanol • Pour point depressant • Monoethylene glycol
Production Operations	• Corrosion inhibitor • Scale inhibitor • Asphaltene inhibitor • Xylene • Methanol • Demulsifier • Defoamer • Floatation aid • Sodium bisulphite • Pour point depressant • Monoethylene glycol	• Polyelectrolyte • Triethylene glycol • Oxygen scavenger • Biocide • Clarifier/coagulant • Hydraulic fluid • Methylene glycol • Diesel (as fuel to power vessels and equipment) • Firefighting foam

[a] The collective term for substances added to drilling fluids when drilling fluids are being lost to the formations downhole

Table 2.13-2: Estimated (Per Well) Project Materials and Chemicals Quantities—Drilling Stage

Chemical Material/Product	Quantity	Units	Quantity	Units	Fate
WBDF	10,500	bbl	1,680	m^3	Seafloor and water column: sacrificial drilling fluid used during the dynamic kill drilling (DKD) interval (28-in interval)
Inorganic salts	94,000	lb	42,676	kg	Water column if used part of the DKD system; in the well if used as part of the completion/packer fluids; overboard (after sheen test is performed) if interface/pills
Barite/bentonite	9,500	cf	269	m^3	Seafloor and water column: sacrificial drilling fluid used during the DKD interval (28-in interval)
Water-soluble biopolymers and modified biopolymers (liquid)	40	bbl	6	m^3	Seafloor and water column: additives for the sacrificial drilling fluid used during the DKD interval (28-in interval) or overboard (after sheen test is performed) if interface/pills
Water-soluble biopolymers and modified biopolymers (solid)	16,100	lb	7,309	kg	Seafloor and water column: additives for the sacrificial drilling fluid used during the DKD interval (28-in interval) overboard (after sheen test is performed) if interface/pills
Thinners	40	bbl	6	m^3	Seafloor and water column: additives for the sacrificial drilling fluid used during the DKD interval (28-in interval)
Calcium carbonate	126,000	lb	57,204	kg	Not discharged: in the NADF as blocking solid when drilling permeable intervals/sands
Lost circulation material	5,500	lb	2,497	kg	Not discharged: in the NADF as a whole system additive or a stand-alone pill to cure lost circulation
Brines	10,000	bbl	1,600	m^3	In the well if used as part of the completion/packer fluids; overboard (after sheen test is performed) if interface/pills
Acids	100	lb	45	kg	In the well if used for stimulation; in the well if used as acid precursor, part of the breaker package
Caustic soda	2,500	lb	1,135	kg	Seafloor and water column: additives for the sacrificial drilling fluid used during the DKD interval (28-in interval)

Chemical Material/Product	Quantity	Units	Quantity	Units	Fate
Surfactants	180	bbl	29	m^3	In the well if used as part of the completion/packer fluids; overboard (after sheen test is performed) if interface/pills
Hydrate inhibitor	6,000	bbl	960	m^3	In the well: packer fluid
Oxygen scavenger	2	bbl	0.3	m^3	In the well: packer fluid
Biocide	15	bbl	2	m^3	Seafloor and water column: additive for the sacrificial drilling fluid used during the DKD interval (28-in interval)
Soda ash	350	lb	159	kg	Seafloor and water column: additive for the sacrificial drilling fluid used during the DKD interval (28-in interval)
NADF with IOGP Group III NABF	8,500	bbl	1,360	m^3	Not discharged: used for drilling and returned to the shore-based mud plant
Emulsifier	170	bbl	27	m^3	Not discharged: additive for the NADF
Non-emulsifier	120	bbl	19	m^3	Not discharged: additive for the NADF
Wetting agent	120	bbl	19	m^3	Not discharged: additive for the NADF
Viscosity modifiers (liquid)	170	bbl	27	m^3	Not discharged: additive for the NADF
Viscosity modifiers (solid)	40,000	lb	18,160	kg	Not discharged: additive for the NADF
Fluid loss modifiers	18,000	lb	8,172	kg	Not discharged: additive for the NADF
Lime	80,000	lb	36,320	kg	Not discharged: additive for the NADF
Corrosion inhibitor	25	bbl	4	m^3	In the well: packer fluid and breaker package
Sand suspension additive	60	bbl	10	m^3	In the well: additive for gravel packing operations
Cement class “G”	400	ton	363	tonne	Small excess cement at the seafloor when cementing the 20-in casing; in the well for all of the subsequent intervals/casing strings
Extender	15	bbl	2	m^3	Small excess at the seafloor when cementing the 20-in casing; In the well for all of the subsequent intervals/casing strings: additive for cement
Defoamer/demulsifier	15	bbl	2	m^3	Small excess at the seafloor when cementing the 20-in casing; In the well for all of the subsequent intervals/casing strings: additive for cement
Retarder	5	bbl	1	m^3	In the well: additive for cement

Chemical Material/Product	Quantity	Units	Quantity	Units	Fate
Dye	2	bbl	0.3	m^3	At the seafloor; used to monitor that cement has covered the entire annular space between 28-in hole and 20-in casing and reached the top of the interval/seafloor
Breaker	550	lb	250	kg	In the well: breaker package used for filter cake removal
Silica flour	50,000	lb	22,700	kg	In the well: additive for cement
Lubricant	3	bbl	0.5	m^3	In the well: additive for cement
Alkalinity control agent	200	lb	91	kg	In the well: additive for cement
Fluids loss control agent	20	bbl	3	m^3	In the well: additive for cement
Filtration medium	5,500	lb	2,497	kg	Not discharged: used for brine filtration during displacement and, when spent, sent to shore in cutting boxes for disposal
Gas control agent	25	bbl	4	m^3	In the well: additive for cement
Diesel (as fuel to power drill ships, vessels, and equipment)	29,000	bbl	4,640	m^3	Not discharged: used for each individual pieces of equipment
Proppant	125,000	lb	56,750	kg	In the well: used for gravel packing operations
Viscoelastic surfactant	70	bbl	11	m^3	In the well: used for gravel packing operations
Rheology modifier	3	bbl	0.5	m^3	In the well: used for gravel packing operations

cf = cubic feet; kg = kilogram; lb = pound

Table 2.13-3: Estimated Project Materials and Chemicals Quantities—Installation Stage

Chemical Material/Product	Quantity	Units	Quantity	Units	Fate
Hydraulic fluid	30	bbl	5	m^3	Discharge to sea, water-soluble, low-toxicity fluid
Nitrogen	20,000,000	scf	566,000	scm	Discharged into reservoir or to sea through gas-injection line commissioning
Hydrate inhibitor (e.g., methanol, ethylene glycol)	3,500	bbl	560	m^3	Discharged either to environment (gas injection, production, and water injection lines) or treated and discharged overboard
Marine gas oil (as fuel to power vessels and equipment)	41,000	bbl	6,560	m^3	Not discharged: used for each individual pieces of equipment
Corrosion inhibitor	100	bbl	16	m^3	Discharged to environment from gas injection line commissioning; injected into water injection wells; injected into production lines, treated and discharged overboard
Scale Inhibitor	160	bbl	26	m^3	Injected into production lines, treated and discharged overboard; injected into water injection wells
Pour point depressant	670	bbl	107	m^3	Injected at downhole injection locations at each subsea well
Asphaltene inhibitor	670	bbl	107	m^3	Injected at downhole injection locations at each subsea well
Xylene	80	bbl	13	m^3	Injected at subsea wellheads and top of risers as needed

scf = standard cubic feet; scm = standard cubic meters

Table 2.13-4: Estimated Project Materials and Chemicals Quantities—Production Operations Stage

Chemical Material/Product	Quantity	Units	Quantity	Units	Fate
Corrosion inhibitor	378,000	bbl	60,480	m^3	Injected to production stream at each production header subsea
Scale inhibitor	25,300	bbl	4,048	m^3	Injected downhole at each subsea well; injected at top of water injection riser during initial water injection well start-up
Pour point depressant	513,600	bbl	82,176	m^3	Injected to production stream at each production header subsea
Asphaltene inhibitor	513,600	bbl	82,176	m^3	Injected downhole at each subsea wells
Xylene	650,000	bbl	104,000	m^3	Injected at subsea wellheads and top of risers as needed
Methanol	626,000	bbl	100,160	m^3	Injected at subsea well heads and manifolds as needed
Demulsifier	29,300	bbl	4,688	m^3	Injected upstream of separator
Defoamer	9.767	bbl	2	m^3	Injected upstream of separator
Floatation aid	7,622	bbl	1,220	m^3	Injected in produced water system to improve oil in water separation
Polyelectrolyte	106	bbl	17	m^3	Also known as clarifier; injected in produced water system to improve oil in water separation
Triethylene glycol	6,743	bbl	1,079	m^3	Used in gas dehydration unit
Oxygen scavenger (sodium bisulphate, SBS)	30,417	bbl	4,867	m^3	Injected at topsides to the WI system
Biocide glutaraldehyde (slops)	7,622	bbl	1,220	m^3	Used for biocide control. Injected to slops tanks
Biocide glutaraldehyde	20,278	bbl	3,244	m^3	Used for biocide control in WI system (including protecting riser /flowlines) Injected upstream of WI pumps
Produced water clarifier	7,622	bbl	1,220	m^3	Injected in produced water system to improve oil in water separation
Coagulant	6,084	bbl	973	m^3	Injected in SW system upstream of MMF to aid in solids removal
Hydraulic power unit fluid	3,273	bbl	524	m^3	Discharge to sea, water-soluble, low-toxicity fluid

Chemical Material/Product	Quantity	Units	Quantity	Units	Fate
Methylene glycol	5,700	bbl	912	m^3	Used at water-alternating-gas manifold barrier system; injected to gas injection riser as necessary
Diesel (as fuel to power vessels and equipment)	76,923	bbl	12,308	m^3	Used as fuel for power vessels
Firefighting foam concentrate	283	cf	8	m^3	Firewater foam header then to Drain System & Slop Tanks, or overboard if required as per regulatory requirements (etc. aviation authorities)

2.13.2. Emissions

The Project will include several sources of atmospheric emissions. The principal sources of atmospheric emissions from the Project operations can be divided into four main categories:

- **Combustion Emissions**: generated from combustion of liquid fuel or natural gas during aviation and marine support and installation activities, operation of the FPSO and drill ships, normal operation of the flare on pilot gas, and non-routine flaring of associated gas that is not used by the FPSO or re-injected into the reservoir;
- **Venting Emissions**: consisting of emissions related to tank storage operations (flashing emissions, standing/working/breathing losses [e.g., FPSO crude oil storage tanks], secondary seals);
- **Vessel-Loading Emissions**: dominated by emissions released during the transfer of crude oil from FPSO to tankers, but also including fuel transfer operations; and
- **Fugitive Emissions**: leakage through process equipment components (e.g., valves, flanges).

Table 2.13-5 provides estimated annual Project atmospheric emissions for three distinct time periods, selected to account for differing activity levels over the Project life. Primary activities in each of these time periods to which the corresponding emissions can be attributed are as follows:

- 2023-2024: Development well drilling, SURF installation and commissioning, FPSO installation, and operation of related support vessels;
- 2025-2027: Continued development well drilling; operation of related support vessels; FPSO start-up and associated temporary, non-routine flaring; beginning of production operations; and tanker loading; and
- 2028–2044: Production operations following start-up, including temporary, non-routine flaring; potential continued development well drilling for up to 5 years into the period; operation of related support vessels; and tanker loading.

For each of the time periods, the annual emissions presented in Table 2.13-5 for each pollutant other than non-methane volatile organic compounds (VOCs) and greenhouse gases (GHGs) represent the maximum anticipated annual emissions for each source during the time period. These source-specific maximum values are not necessarily all from the same year in the time period. While there are some differences in pollutant emissions for different years within the time periods, they are relatively minor and the use of maximum emissions for the impact assessment provides a degree of conservatism in the results. In the case of non-methane VOCs, the source-specific emissions for each time period are all from the same year (i.e., 2024, 2026, and 2029). In the case of GHGs, the source-specific emissions for the first two time periods are all from the same year within the time period (i.e., 2024 and 2026). These are the years with the maximum anticipated annual GHG emissions for any of the years during the

respective time periods. For the third time period, the GHG emissions are the average annual emissions across the time period.

The Project emissions estimates account for an assumed quantity of emissions from low-level continuous flaring of pilot gas, purge gas, and other *de minimis* streams described in this chapter, as well as temporary, non-routine flaring associated in part with upsets and maintenance, and other non-routine and/or unplanned events during the Project life cycle. Estimated emissions from non-routine flaring are included together with estimated emissions from planned activities. As described in Section 2.7.5.3, emission estimates are provided for two cases designated as the “Design Case” and the “Modeled Case” in order for the assessment to consider both non-routine flaring in accordance with design assumptions and a credible worst case for non-routine flaring. The emissions estimates for both cases account for a reduced duration of flaring during non-routine events as a result of the additional compression sparing that has been included in the Project design. With respect to start-up, the Project is targeting 60 cumulative days for start-up flaring, recognizing that this would represent industry-leading performance. For the purpose of this EIA, the estimated emissions are based on the conservative assumption that start-up flaring for the Project will be temporary and may require flaring for 90 cumulative days at the rate of 120 MMscfd.

Table 2.13-5: Estimated Annual Atmospheric Emissions Summary

Pollutant	Source Category	Design Case			Modeled Case		
		Maximum Annual Emissions (tonnes) [a,c]			Maximum Annual Emissions (tonnes) [a,c]		
		2023–2024	2025–2027	2028–2044 [f]	2023–2024	2025–2027	2028–2044 [f]
Nitrogen Oxides	FPSO	0	2,065	2,460	0	2,065	2,460
	FPSO Flaring (temporary, non-routine)	0	505	190	0	520	350
	Tanker Loading	0	240	240	0	240	240
	Area Sources [d]	2,135	1,785	880	2,135	1,785	880
	Drill Ships	1,835	945	1,415	1,835	945	1,415
	Total	3,970	5,540	5,185	3,970	5,555	5,345
Sulfur Dioxide	FPSO	0	110	125	0	110	125
	FPSO Flaring (temporary, non-routine)	0	90	35	0	90	60
	Tanker Loading	0	10	10	0	10	10
	Area Sources [d]	50	65	35	50	65	35
	Drill Ships	65	35	50	65	35	50
	Total	115	310	255	115	310	280
Particulate Matter (PM) [b]	FPSO	0	40	40	0	40	40
	FPSO Flaring (temporary, non-routine)	0	100	40	0	105	70
	Tanker Loading	0	20	20	0	20	20
	Area Sources [d]	100	130	65	100	130	65
	Drill Ships	130	70	100	130	70	100
	Total	230	360	265	230	365	295
Carbon Monoxide	FPSO	0	415	515	0	415	515
	FPSO Flaring (temporary, non-routine)	0	2,300	860	0	2,360	1,585

Pollutant	Source Category	Design Case			Modeled Case		
		Maximum Annual Emissions (tonnes) [a,c]			Maximum Annual Emissions (tonnes) [a,c]		
		2023–2024	2025–2027	2028–2044 [f]	2023–2024	2025–2027	2028–2044 [f]
	Tanker Loading	0	65	65	0	65	65
	Area Sources [d]	565	470	230	565	470	230
	Drill Ships	490	255	380	490	255	380
	Total	1,055	3,505	2,050	1,055	3,565	2,775
Hydrogen Sulfide	FPSO Flaring (temporary, non-routine)	NA (no emissions)	<5	<1	NA (no emissions)	<5	<1
Non-methane Volatile Organic Compounds (VOCs)	All Sources	30	3,500	2,370	30	3,555	2,955
Greenhouse Gases (GHGs) (kilotonnes carbon dioxide-equivalents)	All Sources	240	1,730	1,110 [e]	240	1,760	1,395 [e]

NA = not applicable

[a] The annual estimated totals generally reflect the current preliminary Project schedule and production profile and remain subject to adjustment. Source category-specific sub-totals are rounded up to the next 5 tonnes and the totals reflect the sum of the rounded sub-totals.

[b] PM emissions represent total PM; for the purpose of the impact assessment, the results from modeling of total PM values were used for comparison to both PM_{10} (particulate matter with aerodynamic diameter of less than 10 micrometers) standards and $PM_{2.5}$ (particulate matter with aerodynamic diameter of less than 2.5 micrometers) standards (a conservative assumption).

[c] The emission rates in this table reflect annual totals. In some cases, the activities generating the emissions are not continuous during the year, or do not operate at full capacity throughout the year. For these sources, the annual emissions reflect this non-continuous operation over the year. However, for the purpose of modeling conducted to compare with short-term (up to 24-hour) guidelines, activities were assumed to be operating at full capacity for the simulated period to reflect maximum possible short-term emission rates.

[d] Area Sources are mobile equipment such as aviation and marine support vessels (besides the FPSO and drill ships) used during drilling; installation, commissioning and start-up; production operations; and decommissioning.

[e] Average annual emissions across the time period

[f] Development well drilling could occur for up to 5 years into the period.

2.13.3. Discharges

The Project will have several planned discharges to water. These planned discharges, based on the preliminary design information, are listed in Tables 2.13-6 and 2.13-7. Potential discharges include drill cuttings and fluids; cement; well completion and treatment fluids; produced water; cooling water; sulfate removal, ultrafiltration, and wash water processing brines; topsides drainage; hydrostatic test water; commissioning fluids; ballast water; BOP testing fluids; sanitary and domestic wastewater and food preparation wastes; and firefighting foam monitor testing discharges, as described below. All Project vessels will be equipped to comply with the water pollution control standards required by the IMO MARPOL 73/78.

- **Drill Cuttings and Fluids**: WBDF, as listed in Table 2.13-1, and associated cuttings will be discharged to the sea without treatment per good international oilfield practice (World Bank 2015). The process for treating and discharging cuttings with residual NADF, as listed in Table 2.13-1, is described in Section 2.5.3, Drilling Fluids and Handling System.
- **Cement**: Cement slurry returns are only expected during the cementing of the first casing string for each development well. The excess spacer and lead slurry will be discharged directly to the seafloor immediately around the well. Excess/unused cement will be discharged to the sea.
- **Well Completion and Treatment Fluids**: Well completion and treatment fluids will be treated and discharged to the sea or shipped to shore for appropriate treatment/disposal per good international oilfield practice (World Bank 2015).
- **Produced Water**: The produced water treating system will collect produced water from process facilities and treat the water prior to discharge overboard, as described in Section 2.7.4.5, Produced Water Treatment.
- **Cooling Water**: Seawater is used to dissipate heat generated by the crude oil and water treating systems, the compression systems, and miscellaneous utility systems. Process hydrocarbon fluids will not come into contact with this seawater. Cooling water will be disposed of overboard at a permitted temperature.
- **Sulfate Removal, Ultrafiltration, and Wash Water Processing Brines**: These brine disposal streams are byproducts of the membrane processes used offshore to generate sulfate-free water for injection and to generate wash water for crude oil desalting and for living quarters' requirements. No treatment of these streams (essentially seawater) is required prior to discharge.
- **Topsides Drainage**: The topsides will have non-hazardous and hazardous drain systems. The hazardous drain system will direct drainage to a slop tank, where oil and water will be gravity separated. Once separated, the oil will be skimmed off the top and sent to the cargo tanks, and the water will be discharged overboard in accordance with treatment specifications. The non-hazardous drain system (e.g., rainwater) will route the drain fluids to the slop tank in the FPSO hull or directly overboard.

- **Hydrostatic Test Water**: Seawater treated with chemicals (e.g., biocides) will be injected in the flowlines and risers to confirm the lines are sealed properly during installation, prior to the flow of hydrocarbons. The treated seawater used for hydrostatic testing of the water and gas re-injection lines will be discharged near the seafloor per good international oilfield practice (World Bank 2015; OSPAR 2021). The treated seawater used for hydrostatic testing of the production lines will be round-trip pigged to the FPSO and will be treated and discharged overboard with produced water.
- **Commissioning / Preservation / Production Fluids**: A hydrate-inhibiting substance (e.g., methanol or ethylene glycol) will be used to prevent formation of hydrates in production and gas re-injection lines during commissioning and during planned and unplanned shutdowns and water-alternating-gas changeovers. The fluids used for the gas re-injection lines will be discharged at the seafloor during commissioning and into the reservoir during planned and unplanned shutdowns, and the fluid used for the production lines during commissioning and planned and unplanned shutdowns will be returned to the FPSO, treated, and discharged overboard.
- **Ballast Water**: Discharges of ballast water will be required for initial FPSO installation and recurring tanker offloading. Un-needed ballast water may be discharged as per the Ballast Water Management Plan.
- **BOP Testing Fluids**: During periodic testing (approximately every 2 to 3 weeks) of the BOP system, approximately 30 barrels (4.8 m^3) of low-toxicity power fluid (i.e., fluid used to hydraulically move the preventers) will be discharged near the seafloor. The typical composition of this fluid is approximately 97 percent water with approximately 3 percent biocide/lubrication/corrosion protection chemicals.
- **Grey Water / Black Water / Food Preparation Wastes**: The Project will provide wastewater treatment for sanitary wastes (black water / sewage) and food preparation wastes in accordance with MARPOL requirements. Treated waste streams will be discharged overboard.
- **Firefighting Foam Monitor Testing Discharges**: During each annual testing event for the firefighting foam monitors on the FPSO, an estimated volume of less than 6 bbl (0.95 m^3) of firefighting foam will be discharged either to the FPSO deck or overboard.

Table 2.13-6 summarizes estimated drilling-related discharges and Table 2.13-7 summarizes commissioning and production-related discharges.

Table 2.13-6: Summary of Drilling and Completion-Related Discharges

Fluid Type	Estimated Discharge Per Well (bbl) [a]	Estimated Discharge Per Well (m^3) [a]
Drill Cuttings Discharges	6,822 to 7,051	1,091 to 1,128
WBDF Discharges	10,000 to 11,000	1,600 to 1,760
NABF Retained on Cuttings	395 to 401[b]	63 to 64[b]
Cement Returns	1,500	240
Completion and Treatment Fluids	5,300	850

[a] Values based on deepest well
[b] When NADF is used, drill cuttings will be treated such that end-of-well maximum-weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings

Table 2.13-7: Summary of Commissioning and Production-Related Discharges

Type of Discharge and Projected Effluent Characteristics [a]	Expected Discharge Volume/Rate [a]	Discharge Criteria	Treatment Required to Meet Criteria?
SURF and FPSO Installation/Commissioning Discharges			
Ballast Water (FPSO initial deballasting)	≤ 550,000 bbl (≤ 87,500 m^3) total	Perform discharge in accordance with IMO requirements	No
Hydrostatic Test Water • Biocide / oxygen scavenger / corrosion inhibitor: 1,500 ppm	65,000 bbl (10,400 m^3) (total volume for all flowlines and risers, occurring throughout SURF commissioning phase)	No visible oil sheen on receiving water	No
Gas Re-injection Line Commissioning Fluids • Hydrate inhibitor (e.g., methanol or ethylene glycol)	1,400 bbl (223 m^3) total volume of hydrate inhibitor component	None	NA
Production Discharges			
Produced Water • Oil and grease • Temperature (55°C at point of discharge) • Residual production and water treatment chemicals: – Scale Inhibitor ≤100 ppm – Corrosion Inhibitor ≤200 ppm • Hydrate inhibitor (e.g., methanol) [c]	≤ 300,000 BPD (≤ 47,700 m^3/d)	Oil-in-water content: 29 mg/L (monthly average); 42 mg/L (daily maximum) Temperature rise <3°C at 100 meters from discharge	Yes
Cooling Water • Hypochlorite: ≤ 5 ppm • Temperature (50°C at point of discharge)	≤ 1,900,000 BPD (≤ 302,100 m^3/d)	No visible oil sheen on receiving water Temperature rise <3°C at 100 meters from discharge	No

Type of Discharge and Projected Effluent Characteristics [a]	Expected Discharge Volume/Rate [a]	Discharge Criteria	Treatment Required to Meet Criteria?
Sulfate Removal, Ultrafiltration, and Wash Water Processing Brines • Hypochlorite: ≤ 1 ppm • Electrolyte: ≤ 1 ppm • Biocide: ≤ 5 ppm • Oxygen scavenger: ≤ 10 ppm • Scale inhibitor: ≤ 5 ppm	≤ 315,000 BPD (≤ 50,100 m^3/d)	None	NA
Subsea Hydraulic Fluid Discharge • Water soluble, low-toxicity	≤ 5 BPD (≤ 0.8 m^3/d)	None	NA
FPSO Bilge Water	1,800 BPD (287 m^3/d)	Oil-in-water content: <15 ppm	Yes
Inert Gas Generator Cooling Water	Negligible	None	NA
FPSO Slop Tank Water (includes off-specification oil from process and deck drainage)	Slop tank water is rainfall dependent, but expected to be negligible [b]	Oil-in-water content: <15 ppm	Yes
Miscellaneous Discharges including Boiler Blowdown, Desalinization Blowdown, Lab Sink Drainage	<10 BPD (<1.6 m^3/d)	None	NA
Tanker Ballast Water	Maximum 629,000 bbl (100,000 m^3) total (at each tanker crude loading)	Perform in accordance with IMO requirements	No
BOP and Subsea BOP System Testing Water-Soluble Low-Toxicity Hydraulic Fluid	30 bbl (4.8 m^3) every 2–3 weeks	None	NA
Grey Water	250 BPD (40 m^3/d)	None	NA
Black Water (sewage)	85 BPD (13.6 m^3/d)	Where chlorination (secondary method following ultraviolet sterilization) is performed, total residual chlorine as low as practical but not less than 1 ppm	Yes
Food Preparation Wastes	<40 BPD (<6.4 m^3/d)	Macerated to <25 mm diameter	Yes
Firefighting Foam Monitor Testing Discharge	<6 bbl (<0.95 m^3) per year (at annual fire monitor testing event)	None	NA

°C = degrees Celsius; bbl = barrel; BPD = barrels per day; mm = millimeter; NA = not applicable
[a] Effluent characteristics and volumes/rates are based on the preliminary Project design information available at the time of the EIA.
[b] FPSO slop tank water includes deck drainage in addition to off-specification oil from the process. While the expected volume of off-specification oil will be negligible, if it rains significantly, the expected discharge volume for this stream will be increased (though the increase would be entirely rainwater).
[c] During production line commissioning and planned and unplanned shutdowns

2.13.4. Wastes

The Project will generate a variety of solid wastes including both hazardous and non-hazardous wastes, which will vary over time by Project stage. As Table 2.13-8 indicates, waste will begin to be generated when drilling commences, in 2023 per the current Project schedule. Waste volumes generated will increase as drilling activity increases in 2024 and 2025. Additional waste will be generated from SURF installation and FPSO commissioning and hook-up activities in the 2024–2025 timeframe. Waste volumes will then begin to decrease as drilling activity declines and will significantly decrease during the production operations stage once drilling activity is complete. When production operations cease, some waste will be generated from decommissioning activities. All Project waste streams will be managed in accordance with the CWMP.

Table 2.13-8: Summary of Estimated Annual Generation for Project Wastes that will be Managed Onshore

Waste Generated by Category	Volume by Year/Metric Tonnes [a]									
	2023	2024	2025	2026	2027	2028	2029	2030	2031-2032	2033-2044
Non-Hazardous wastes (total) [b, c]	750	1,900	2,030	1,670	1,670	1,670	1,670	110	1,670	110
Hazardous wastes (total) [b, d]	300	2,360	3,270	700	700	700	700	100	700	100

[a] The annual totals reflect the current preliminary Project schedule and production profile, which could change. Annual totals conservatively assume drilling up to 2032.
[b] Totals may not sum exactly due to rounding.
[c] Includes wastes that will be directly shipped to an approved landfill and wastes that can be recycled, reclaimed, or reused. Volumes include estimated quantities of residue from treatment of hazardous waste.
[d] Includes wastes that are treated to produce residual non-hazardous effluent than can be discharged through permitted outfalls and wastes that are treated to produce residual non-hazardous solid wastes that can then be recycled, reclaimed, or reused, or transported for disposal in an approved landfill.

2.13.5. Radiation Emission Sources

Radiation sources and radiation-producing devices imported and used by the Project and its contractors may potentially include radiographic equipment (e.g., welding inspection application), certain types of process instrumentation (such as level gauges), and certain types of lab equipment (e.g., crude oil testing application). As of the submission date of the EIA, consideration is being given to incorporating radiation source(s) on the FPSO to assist with level measurements on the HP, LP, and test separators; if such equipment is used on the FPSO, the controls described below would be applied.

The Project will follow good international oilfield practice to manage any workforce or third-party exposure to NORM or radiography sources. Any equipment containing such sources will be registered, strictly tracked, controlled, and returned to the vendor at the end of its use or if it must be replaced at any time.

EEPGL and the FPSO operator will have a Radiation Management System that addresses NORM. Breaks in containment will require internal surfaces to be checked for the presence of NORM. This will take place during the initial breaking of containment and as plant/equipment are disassembled (e.g., whenever new internal surfaces are exposed). The International Atomic Energy Agency's Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards GSR Part 3 2014 Edition (IAEA 2014) recommends that certain records are to be kept and maintained when radioactive substances are kept, used, transported, and/or disposed of.

An assessment of the external radiation risk associated with the use and handling of the source will also be carried out. If this risk assessment indicates potential exposure to any member of the workforce in excess of 1 milliSievert per year, a Supervised Area will be established. Signs giving warning of the Supervised Area will be displayed in suitable positions indicating the nature of the radiation sources and the risks arising from such sources. If the levels exceed 7.5 microSieverts per hour (µSv/h), a Controlled Area will be set up at the 7.5 µSv/h contour.

Clear hazard warning labeling of equipment or materials to be sent offsite that may have residual NORM contamination will be provided. Signs giving warning of the Supervised Area will be displayed in suitable positions indicating the nature of the radiation sources and the risks arising from such sources. Management of any wastes with residual NORM contamination will be conducted in accordance with the CWMP and by qualified waste contractors, including during storage pending final transfer to a permitted and approved disposal facility.

The Project may potentially produce small amounts of NORM from the reservoir over the life of the production operations stage. NORM can sometimes be found in trace concentrations in underground formations and in oil and gas production streams. NORM from production reservoirs can accumulate within production equipment (vessels, piping, valves, etc.) as a scale or sludge. It is not yet known whether the crude that will be extracted for the Project will contain NORM at some point during production operations; this will be determined via monitoring conducted during production operations.

To manage occupational health risks associated with radiation, EEPGL and its contractors will apply standard industry health controls. Typical radiation-related health controls, which can be variable depending on the application, may include:

- Compliance with local regulations, including administrative controls related to importation permits and licensing;
- Adherence to procedures to manage radioactive sources, including:
  - API 17S Recommended Practice for the Design, Testing, and Operation of Subsea Multiphase Flow Meters
  - IAEA TS-R-1 Regulations for the Safe Transport of Radioactive Material
  - BSI BS EN ISO 361 Basic Ionizing Radiation Symbol
  - EP-HSE-PMS-SAF-SAF.GRP.INS.0059.ENG, Radiation Management

- Use of a qualified Radiation Safety Officer;
- Use of site inventory for radiation sources;
- Clearly labeled radiation sources managed under a chain of custody protocol;
- PPE;
- Barricading and signs;
- Personnel exposure monitoring procedures;
- Medical surveillance for identified personnel;
- Radiography performed outside of common work areas or at lower workforce exposure times (i.e., night shift) where feasible;
- Documented baseline surveys for facilities with NORM;
- Exposure control practices for personnel where NORM is present (i.e., for line breaks);
- Clear hazard warning labeling of equipment or materials sent offsite that may have residual NORM contamination;
- Management of any wastes with residual NORM contamination by a qualified waste contractor;
- Training requirements; and
- Emergency procedures for source damage/loss.

2.14. EMBEDDED CONTROLS

EEPGL has incorporated the embedded controls[23] provided in Table 2.14-1 into the Project.

Table 2.14-1: Embedded Controls Incorporated into the Project

Embedded Controls	Resources/Receptors Benefited
Development Well Drilling and SURF/FPSO Installation and Commissioning	
Use water-based drilling fluids to the extent reasonably practicable (upper sections of the wells). For well sections requiring NADF, use only low-toxicity IOGP III base fluid.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
When NADF is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
Install a BOP system that can be closed rapidly in the event of an uncontrolled influx of formation fluids and that allows the well to be	Marine geology and sediments, marine water quality, coastal habitats, marine mammals, marine

[23] Embedded controls are physical or procedural controls that are planned as part of the Project design (i.e., not added solely based on a mitigation need identified by the impact significance assignment process). These are considered from the very start of the impact assessment process as part of the Project, and are factored in to the pre-mitigation impact significance rating.

Embedded Controls	Resources/Receptors Benefited
circulated to safety by venting the gas at surface and routing oil so that it may be contained.	turtles, marine fish, seabirds, marine benthos
Test BOP equipment at installation, after disconnection or repair of any pressure containment seal, and at regular intervals (at least every 21 days or as operations allow).	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
Employ trained Marine Mammal Observers during the conduct of seismic-related activities.	Marine mammals, marine turtles
Conduct a continuous observation of a mitigation zone (500 meters [1,640 feet] around the sound source) to verify whether it is clear of marine mammals and marine turtles before commencing sound producing seismic operations. Do not conduct sound-producing seismic operations (including soft starts) if marine mammals or turtles are sighted within the mitigation zone during the 30 minutes prior to commencing sound-producing operations in water depths less than 200 meters [656 feet], or 60 minutes prior to commencing sound-producing operations in water depths greater than 200 meters [656 feet].	Marine mammals, marine turtles
Where reasonably practicable, equip sound-making devices or equipment with silencers or mufflers that are enclosed, and/or use soft-start procedures (e.g., for vertical seismic profiling, etc.) to reduce noise to levels that do not cause material harm or injury to marine species.	Marine mammals, marine fish, marine turtles
Adhere to the Joint Nature Conservation Committee guidelines (JNCC 2017) during the conduct of seismic-related activities.	Marine mammals, marine turtles
If well testing[24] is performed, implement the following measures: • Flow only the minimum volume of hydrocarbons required for the test and reduce the test duration to the extent practical. • Use an efficient test-flare burner head equipped with an appropriate combustion enhancement system to minimize incomplete combustion, black smoke, and hydrocarbon fallout[25] to the sea. • Provide adequate gas sensors that are appropriately located during testing operations, so that all sources of gas can be detected. • Monitor pipes and joints on a daily basis for leakages and fugitive emissions. Burn all collected gaseous streams in high-efficiency flares, and implement and maintain a leak detection and repair program. • Keep the well test to the minimum practical time, in keeping with a pre-approved schedule with the EPA. Notify the EPA immediately in case of any deviation/variation to the well test • Provide sufficient compressed air to the oil burner for efficient flaring assignment.	Air quality, climate, and climate change

[24] While well testing is not planned for the Project, there is the potential it could be needed, in which case EEPGL will implement the measures in Table 2.14-1

[25] Hydrocarbons that are deposited on the ocean surface due to both wet and dry deposition processes

Embedded Controls	Resources/Receptors Benefited
With respect to prevention of spills of hydrocarbons and chemicals during the drilling stage: • Change liquid hydrocarbon transfer hoses periodically; • Use dry-break connections on liquid hydrocarbon bulk transfer hoses; • Perform required inspections and testing of all equipment prior to deployment/installation; • Use overbalanced drilling fluids to control wells while drilling; • Perform operational training certification (including well-control training) for drill ship supervisors and engineers; • Use controls for mitigating a failure of the Dynamic Positioning (DP) system on the drill ships and maintaining station-keeping, which include: – Use of a Class 3 DP system, which includes numerous redundancies; – Rigorous personnel qualifications and training; – Sea trials and acceptance criteria; – Continuous DP proving trials; – System Failure Mode and Effects Analysis; – Continuous DP failure consequence analysis; and – Establishment of well-specific operations guidelines.	Marine geology and sediments, marine water quality, protected areas and special status species, coastal habitats, coastal wildlife, marine mammals, marine turtles, marine fish, marine benthos, ecological balance and ecosystems
Prior to and post-drilling, an ROV will take pictures of the area immediately surrounding the well location to monitor for marine water quality impacts.	Marine geology and sediments, marine water quality, protected areas and special status species, marine mammals, marine turtles, marine fish, marine benthos, ecological balance and ecosystems
Maintain marine safety exclusion zones to be issued through MARAD with a 500-meter (approximately 1,640-foot) radius around drill ships and major installation vessels, to prevent unauthorized vessels from entering areas with an elevated risk of collision.	Marine use and transportation
For all vessel effluent discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with IMO and MARPOL 73/78 requirements.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Install subsea BOP systems consisting of one annular preventer, two shear ram preventers—one of which must be sealing, and two pipe ram preventers, and equip them with choke and kill lines and failsafe choke and kill close valves.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Facility personnel should conduct bi-weekly well-control drills, or as operations allow, which should be attended by key personnel.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Utilize a BOP that is able to close on the maximum outside diameter drill pipe string used for the drilling operations and that contains a safety system to secure the well in the event of a loss of control signal and hydraulic supply from the surface to the BOP. At a minimum, subsea BOP systems should allow closure of one set of pipe rams and blind-shearing type rams by ROV intervention if required.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Prepare contingency plans for well operations that include identification of provisions for well capping in the event of	Marine geology and sediments, marine water quality, marine

Embedded Controls	Resources/Receptors Benefited
uncontrolled blowout (providing indication of the tools, equipment, and intervention time required) and identification of spill recovery measures.	mammals, marine turtles, marine fish, marine benthos, seabirds
Production Operations	
Use aero-derivative turbines instead of industrial turbines on the FPSO.	Air quality, climate, and climate change
Install waste heat recovery units on turbine generators to reduce the demand of more power generation or fired heaters, thus decreasing fuel gas consumption.	Air quality, climate, and climate change
Use a crude–crude exchanger to recover heat from the dead crude to heat up live crude, instead of using a fired heater.	Air quality, climate, and climate change
Use a gas turbine to drive the export/injection compressors directly, allowing savings in fuel versus using a gas turbine to generate electricity, and then using an electric motor to drive the compressor—reducing motor losses and power generation losses.	Air quality, climate, and climate change
Use large, high-voltage motors, which are more efficient than industry standard machines.	Air quality, climate, and climate change
Provide installed spares on compressors for the Flash Gas Compression, Main Gas Compression, and Re-injection Gas Compression systems, such that when one compressor trips, the spare unit can be started, hence reducing non-routine flaring frequency and volume/duration.	Air quality, climate, and climate change
Implement an FPSO topsides leak detection and repair program to reduce fugitive emissions.	Air quality, climate, and climate change
Implement a flare minimization plan for the Project.	Air quality, climate, and climate change
Instead of continuous flaring of gas produced during crude oil production, re-inject associated gas that is not used as fuel gas on the FPSO—excluding other *de minimis* sources not captured by the VRU—into the reservoir, to avoid routine flaring of associated gas.	Air quality, climate, and climate change
Use highly efficient combustion equipment that utilizes recovery heat systems as part of the heat and power production.	Air quality, climate, and climate change
With respect to non-routine flaring of associated gas, the following measures will be implemented: • Properly inspect, maintain, monitor, certify, and function-test flare equipment prior to and throughout operations; • Design and build combustion equipment to appropriate engineering codes and standards; • Use flare tip of a non-pollutant type, with low NOx emissions, and a burning efficiency high enough to support low hydrocarbon emissions to the atmosphere; • Minimize risk of pilot blowout by ensuring sufficient exit velocity and provision of wind guards; • Use a reliable pilot ignition system; • Install high-reliability instrument pressure protection systems, as appropriate, to reduce overpressure events and avoid or reduce flaring situations; • Minimize liquid carryover and entrainment in the gas flare stream with a suitable liquid separation system, with sufficient holding	Air quality, climate, and climate change

Embedded Controls	Resources/Receptors Benefited
capacity for liquids that may accumulate, and which is designed in accordance with good international oilfield practice (World Bank 2015); • Equip liquid separation system (e.g., knockout drum) with high-level facility shutdown or high-level alarms and empty as needed to increase flare combustion efficiency; • Implement source gas reduction measures (i.e., gas re-injection into reservoir) to the extent possible to avoid or reduce flaring from FPSO; • Minimize flaring from purges and pilots without compromising safety through measures such as installation of purge gas reduction devices, VRUs, inert purge gas, and soft seat-valve technology where appropriate, and installation of pilot flares; and • Minimize flame lift off and/or flame lick.	
Employ reasonable efforts and execute a maintenance program to minimize equipment breakdowns and plant upsets that could result in flaring, and make provisions for equipment sparing and plant turn-down protocols where practical.	Air quality, climate, and climate change
Implement inspection, maintenance, and surveillance programs to identify and prevent unplanned emissions to atmosphere onboard the FPSO.	Air quality, climate, and climate change
Adopt measures as far as practicable, in accordance with the Global Gas Flaring and Venting Reduction Partnership, when considering venting and flaring options under emergency or upset conditions.	Air quality, climate, and climate change
Avoid routine venting (excludes tank flashing emissions, standing/working/breathing losses, secondary seals) except during safety and emergency conditions.	Air quality, climate, and climate change
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 mg/L on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored and the discharge meets the noted specification.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C (5.4°F) at 100 meters (approximately 328 feet) from discharge point.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Monitor residual chlorine concentration of sewage discharges from the FPSO monthly to stay below 0.5 mg/L in accordance with MARPOL 73/78 regulations.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
For effluent released from the onboard sewage treatment plant, comply with aquatic discharge standards in accordance with MARPOL 73/78 regulations.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems

Embedded Controls	Resources/Receptors Benefited
Perform daily visual inspections on the FPSO of discharge points to verify that there are no floating solids or discoloration of the surrounding waters.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Maintain marine safety exclusion zones to be issued through MARAD with a 2-nautical-mile (approximately 12,150-foot) radius around FPSO during offloading operations, to prevent unauthorized vessels from entering areas with an elevated risk of collision.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Employ dedicated Mooring Master to supervise offloading activities, according to the conditions of the sea. The conditions and characteristics of the export tankers will be assessed by the Mooring Master and reported to the Offshore Field Manager prior to commencing offloading operations. Use only properly registered and well-maintained double-hull vessels.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use support tugs to aid tankers in maintaining station during approach/departure from FPSO and during offloading operations.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Adopt risk assessment processes (e.g., hazard and operability study, hazard identifications study, etc.) to assess risks associated with process upset and loss-of-containment events which could impact the environment.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use a hawser with a quick release mechanism to moor the FPSO to the tanker at a safe separation distance during offloading operations.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Establish operating conditions for FPSO offloading to tankers to support safe operations. In the event that adverse weather occurs during offloading operations that is beyond the environmental operating limit, the tanker will cease offloading operations, and may disconnect and safely maneuver away from the FPSO as appropriate.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use breakaway couplers on offloading hose that would stop the flow of oil from FPSO during an emergency disconnect scenario.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use a liquid hydrocarbon checklist before every bulk transfer.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use a load-monitoring system in the FPSO control room to support FPSO offloading.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Utilize procedures for loading, storage, processing, and offloading operations, either for consumables (i.e., fuel, drilling fluids, and additives) or for liquid products, to minimize spill risks. Inspect	Marine geology and sediments, marine water quality, marine

Embedded Controls	Resources/Receptors Benefited
pumps, hoses, and valves on a monthly basis, and perform maintenance as needed.	mammals, marine turtles, marine fish, marine benthos, seabirds
Use leak detection controls during FPSO offloading (e.g., for breach of floating hose, instrumentation/procedures to perform volumetric checks).	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Install an Emergency Shutdown System on the FPSO to initiate automatic shutdown actions to bring the offshore facility to a safe condition and which should be activated in case of any significant release.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Implement a corrosion management system to monitor risks and identify corrective actions in the atmospheric zone, splash zone, submerged zone, and internal zones.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Inspect and maintain onboard equipment (engines, compressors, generators, STP, and oil-water separators) in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, in order to maximize efficiency and minimize malfunctions, and unnecessary discharges into the environment.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use low-sulfur (less than 0.5 percent sulfur content) fuels and/or natural gas on all Project vessels in turbines, reciprocating engines, or boilers used for heat or power generation or to drive machinery such as compressors or pumps.	Air quality, climate, and climate change
Abide with IMO (2004) guidelines including the International Convention for the Control and Management of Ship's Ballast Water and Sediments, with the exception of Regulation D-2 (Ballast Water Performance Standard) while the FPSO is on station, and abide with MARPOL 73/78.	Ecological balance and ecosystems
General Measures	
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.	Air quality, climate, and climate change; sound; marine water quality; marine mammals; marine turtles; riverine mammals
Implement engineering controls, administrative controls, and training to protect offshore workforce from high noise levels in the offshore work environment.	Sound
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Equip Project vessels with radar systems and communication mechanisms to communicate with third-party mariners.	Marine use and transportation
Shut down (or throttle down) sources of combustion equipment in intermittent use where reasonably practicable in order to reduce air emissions.	Air quality, climate, and climate change
Implement chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances. The chemical selection process is	Air quality, climate, and climate change; marine water quality; marine geology and sediments;

Embedded Controls	Resources/Receptors Benefited
aligned with applicable Guyanese laws and regulations and includes: • Review of safety data sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.	marine mammals; marine turtles; riverine mammals; marine fish; marine benthos; seabirds
Utilize low toxicity chemicals/materials where practical. Each chemical/material should be managed in accordance with the associated Safety Data Sheet.	Air quality, climate, and climate change, marine water quality, marine geology and sediments, marine mammals, marine turtles, riverine mammals, marine fish, marine benthos, seabirds
Use secondary containment for storage of bulk fuel, drilling fluids, and hazardous materials, where reasonably practicable.	Marine water quality
Regularly (e.g., monthly) check pipes, storage tanks, and other equipment associated with storage or transfer of hydrocarbons/chemicals for leaks and fugitive emissions.	Marine water quality
For effluent released from the onboard STP, comply with aquatic discharge standards in accordance with MARPOL 73/78 regulations.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter (approximately 1-inch-diameter) particle size or less) prior to discharge.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
For transport of hazardous and nonhazardous wastes offsite for treatment or disposal, confirm the waste is accompanied by a manifest signed by the hazardous waste generator, transporter, and receiving facility.	Waste management infrastructure capacity
Return radioactive sources to their supplier and manage radioactive sources in accordance with environmental permits and applicable safety standards.	Waste management infrastructure capacity
Secure and contain fuel, oils, and chemicals in accordance with their Safety Data Sheet recommendations.	Waste management infrastructure capacity
Provide for adequate onshore waste-management equipment and facilities for the proper management of waste in accordance with local regulation and good international oilfield practice.	Waste management infrastructure capacity
For wastes that cannot be reused, treated, or discharged/disposed on the drill ships or FPSO, properly manifest and transfer such wastes to appropriate onshore facilities for management.	Waste management infrastructure capacity
Sample and perform analytical testing as needed to properly classify waste.	Waste management infrastructure capacity
Complete Recoverable Material and Waste Summaries.	Waste management infrastructure capacity
Periodically audit waste contractors to verify appropriate waste management practices are being used.	Waste management infrastructure capacity

Embedded Controls	Resources/Receptors Benefited
Record type and quantity of each individual waste stream on board vessels any time a new waste is generated.	Waste management infrastructure capacity
Inspect on a regular basis waste storage areas and containers; log inspections.	Waste management infrastructure capacity
Avoid, reduce, and reuse/recycle wastes preferentially prior to disposal in accordance with waste management hierarchy.	Waste management infrastructure capacity
Perform onshore waste treatment for certain categories of waste, thereby reducing demand on landfill capacity.	Waste management infrastructure capacity
Confirm there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge. Perform daily inspections to verify no visible sheen from discharge of cooling water.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Treat bilge water in accordance with MARPOL 73/78 to comply with an oil-in-water content of less than 15 ppm, as applicable. Perform oil-in-water content (automatic) monitoring of bilge water to verify compliance with 15 ppm and record in Oil Record Book.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals and riverine mammals at the sea surface. Provide standing instruction to Project-dedicated vessel masters to avoid marine mammals, riverine mammals, and marine turtles while underway and reduce speed or deviate from course, when possible, to reduce probability of collisions.	Marine mammals, marine turtles, riverine mammals
Provide standing instruction to Project-dedicated vessel masters to avoid any identified rafting seabirds when transiting to and from PDA.	Seabirds
Provide standing instructions to Project-dedicated vessel masters to reduce their speed within 300 meters (984 feet) of observed marine mammals and marine turtles, and to not approach the animals closer than 100 meters (328 feet).	Marine turtles
Observe standard international and local navigation procedures in and around the Georgetown Harbour and Demerara River, as well as best ship-keeping and navigation practices while at sea.	Marine use and transportation
Provide health-screening procedures to Project workers to reduce risks of transmitting communicable diseases.	Community health and wellbeing
Monitor Project workers' occupational exposure to sound.	Community health and wellbeing
Test for diseases that are communicable through normal medical screening/surveillance.	Community health and wellbeing
Employ Guyanese citizens having the appropriate qualifications and experience where reasonably practicable.	Socioeconomic conditions, employment and livelihoods
Partner with select local institutions and agencies to support workforce development programs targeted to in-demand skillsets, and proactively message Project-related employment opportunities.	Socioeconomic conditions, employment and livelihoods
Procure Project goods and services from Guyanese suppliers when available on a timely basis and when they meet minimum standards and are commercially competitive.	Socioeconomic conditions, employment and livelihoods
Monitor percentage of Project Workforce made up of Guyanese nationals on a quarterly basis.	Socioeconomic conditions, employment and livelihoods

Embedded Controls	Resources/Receptors Benefited
Monitor percentage of Project goods and services expenditures procured locally on a quarterly basis.	Socioeconomic conditions, employment and livelihoods
Develop and implement a Stakeholder Engagement Plan.	Community health and wellbeing
Implement a transparent, accessible, and consistent Community Grievance Mechanism (CGM) early on, prior to onset of Project activities.	Community health and wellbeing
Monitor grievances received and resolved by the CGM; adjust CGM and other management measures, as appropriate.	Community health and wellbeing
Implement a community safety program for potentially impacted schools and neighborhoods to increase awareness and minimize potential for community impacts due to vehicle incidents.	Social infrastructure and services, community health and wellbeing
Implement a Road Safety Management Procedure to mitigate increased risk of vehicular accidents associated with Project-related ground transportation activities. The Road Safety Management Procedure has been implemented as of the writing of this EIA, and the procedure includes the following components: • Definition of typical, primary travel routes for ground transportation in Georgetown area; • Development of an onshore logistics/journey management plan to reduce potential conflicts with local road traffic when transporting goods to/from onshore support facilities; • Definition of required driver training for Project-dedicated drivers, including (but not limited to) defensive driving, loading/unloading procedures, and safe transport of passengers, as applicable; • Designation and enforcement of speed limits through speed governors, global positioning system, or other monitoring systems for Project-dedicated vehicles; • Avoidance of deliveries during typical peak-traffic hours as well as scheduled openings of the Demerara Harbour Bridge, to the extent reasonably practicable; • Monitoring and management of driver fatigue; • Definition of vehicle inspection and maintenance protocols that include all applicable safety equipment for Project-dedicated vehicles; and • Community outreach to communicate information relating to major delivery events or periods.	Social infrastructure and services, community health and wellbeing
Coordinate with relevant aviation authorities and stakeholders to understand peak Project-related utilization rates.	Social infrastructure and services
Use an established Safety, Security, Health, and Environment program to which all Project workers and contractors will be required to adhere to mitigate against risk of occupational hazards. Require all workers and contractors to receive training on implementation of these principles and to adhere to them in the daily execution of their duties.	Occupational health and safety
Maintain an Oil Spill Response Plan to support an effective response to an oil spill, including maintaining the equipment and other resources specified in the Oil Spill Response Plan. Conduct periodic inspections, training, and drills including monthly inspection of oil spill response equipment, quarterly test runs of oil spill response equipment, annual preventive maintenance program	All resources and receptors potentially impacted by an oil spill

Embedded Controls	Resources/Receptors Benefited
execution, and annual exercise and deployment of oil spill response equipment to test readiness and response capability.	
Where reasonably practicable, direct lighting on FPSO and major Project vessels to required operational areas rather than at the sea surface or skyward. Adhere to maritime safety regulations/standards for lighting on vessels.	Seabirds, marine turtles
Provide screening for seawater intakes to avoid entrainment and impingement of marine flora and fauna.	Marine fish

°C = degrees Celsius

2.15. WORKER HEALTH AND SAFETY

EEPGL is committed to protecting the safety, security, and health of its employees, contractors, and the public, with a goal of *Nobody Gets Hurt*. Consistent with this commitment, the Project will employ a robust and effective management system to protect its Project workforce. EEPGL will implement its Operations Integrity Management System. The Occupational Health and Risk Assessment & Management portions of the system are designed to manage occupational risks to workers (see Section 2.4, Overview of the Development Concept) during each stage of the Project. Additional information regarding EEPGL's occupational safety and health program is provided in the Project Environmental and Socioeconomic Management Plan (ESMP).

2.16. PURPOSE AND NEED OF THE PROJECT

The Project is being developed to achieve safe and efficient production of hydrocarbons from reservoirs in the Stabroek Block. The Yellowtail Project, as the fourth petroleum development project in Guyana, will generate revenues for Guyana and the Project participants; enhance and grow Guyana's upstream petroleum industry; and create jobs, investment, and capacity building for the Guyanese community (local content). Previous Stabroek Block development projects have to date brought more than $87.2 billion GYD ($436 million USD) in direct revenue to Guyana (Bryan 2021). These petroleum operations have created opportunities for more than 2,600 Guyanese who currently support project activities onshore and offshore, and for more than 800 local companies who have received more than &77.6 billion GYD ($388 million USD) from spending on these projects (ExxonMobil 2021). The Project is expected to add to these opportunities.

2.17. PROJECT BENEFITS

The Project will generate benefits for the citizens of Guyana in several ways, including:

- Through revenue sharing with the Government of Guyana, as detailed in the PA between the Government of Guyana and EEPGL et al., which was made available to the public in December 2017. The type and extent of benefits associated with revenue sharing will depend on how decision makers in government decide to prioritize and allocate funding for future programs, which is unknown to EEPGL and outside the scope of the EIA.

- By procuring select Project goods and services from Guyanese businesses in alignment with the PA and the EEPGL Local Content Plan approved by the Ministry of Natural Resources in June 2021.
- By hiring Guyanese nationals in alignment with the PA and the EEPGL Local Content Plan.
- By capacity building such as the Greater Guyana Initiative (Stabroek Partners), which includes programs supporting the University of Guyana, technical schools, and business development for greater economic growth.

In addition to direct revenue sharing, expenditures, and employment, the Project will also likely generate induced economic benefits. These induced benefits result from the re-investment, hiring, and spending by Project-related businesses and/or workers, which in turn benefits other non-Project-related businesses and generates more local tax for the government. These beneficial "multiplier" impacts are expected to occur throughout the Project life.

2.18. ALTERNATIVES

This section describes the alternatives to the proposed Project that were considered, including the following:

- Location alternatives
- Development concept alternatives
- Technology and process alternatives
- No action alternative

2.18.1. Location Alternatives

The location of the offshore Project infrastructure, particularly the development wells and SURF hardware, is primarily driven by the location of the resource to be recovered. Accordingly, there are no feasible alternative PDA locations that could effectively recover the resource. However, within the proximity of the resource, there is some flexibility in selecting the location of the FPSO and associated mooring system. This section discusses the drivers for selecting an FPSO location and the alternative locations that were considered.

The Yellowtail FPSO will be located approximately 31 kilometers (19.3 miles), 22 kilometers (13.7 miles), and 41 kilometers (25 miles), respectively, from the Liza Phase 1, Liza Phase 2, and Payara FPSOs. The Yellowtail Surface PDA will be separated by approximately 23 kilometers (14.3 miles), 14.4 kilometers (8.9 miles), and 25.1 kilometers (15.6 miles), respectively, from the Liza Phase 1, Liza Phase 2, and Payara Surface PDAs. The Yellowtail Subsea PDA will be separated by approximately 27.2 kilometers (16.9 miles), 18.4 kilometers (11.3 miles), and 26.1 kilometers (16.2 miles), respectively, from the Liza Phase 1, Liza Phase 2, and Payara Subsea PDAs.

A key consideration for the FPSO location is to minimize interference with four-dimensional (4D) seismic operations. To assist in maximizing resource recovery, EEPGL intends to perform 4D seismic over the Yellowtail and Redtail fields. 4D seismic operations consist of regular, identical, high-resolution seismic shoots conducted at regular intervals throughout the life of the field. The

data from this operation will allow EEPGL to assess the movement of fluid contacts over time, which will in turn support planning future drilling to target areas with remaining oil. The FPSO would represent an obstacle in gathering 4D seismic data and would leave a "shadow" if it were located above the Yellowtail or Redtail fields. It is therefore important that the FPSO is not located directly over the Yellowtail or Redtail fields, in order to allow maximum coverage by 4D seismic.

A further factor for FPSO location related to 4D seismic is positioning the FPSO so as to facilitate efficient 4D seismic operations. The 4D seismic vessel must maneuver around the FPSO, and the FPSO location therefore needs to consider this, recognizing the challenges in maneuvering a seismic vessel and its approximately 10-kilometer (6.2-mile) array towed behind it.

Another consideration for the FPSO location is to avoid positioning FPSO anchor piles in areas that could create geotechnical challenges (e.g., maintaining a distance from any shallow canyons, seabed characteristics that indicate greater potential for rafted blocks, other features that could significantly increase the complexity and risk of anchor pile design and execution).

Additional considerations include assessment of seabed slopes relative to SURF layout, to avoid areas of potential slope instability and with a preference for flowlines to ideally have an uphill run toward the FPSO. The primary mitigation strategy to avoid areas with potential stability concerns has been adjustment of the subsea infrastructure layout to avoid these features based on geophysical analysis. Potential seafloor instabilities, such as slope instability, have already been mapped in the Yellowtail field based on geophysical studies, and the results of this mapping have been incorporated in the Yellowtail design process for subsea infrastructure. Interpretation of additional geotechnical study data (ongoing as of the time of the EIA) will provide further data regarding potential slope stability concerns, and the subsea infrastructure will be further adjusted, as needed, based on the review of these data. EEPGL is in the process of collecting these additional data to corroborate the current expectation that the last movement occurred sufficiently long ago that further movement of the seabed is not anticipated within the design life of the Project. Locating flowlines to create uphill runs to the FPSO is important in reducing system slugging[26], which can have material impacts on the design and operation of the FPSO.

The Project will require approximately 45 to 67 wells, comprising a combination of producers and injectors. The bottom-hole location for each well will be selected to maximize recovery from the Yellowtail and Redtail fields, based on extensive subsurface modeling. At the seabed, each well will be tied back to a manifold, which reduces the Project footprint and cost relative to tying back each well individually. Manifold locations are selected to minimize overall drilling length and hence drilling cost. Given the aerial extent of the Yellowtail and Redtail fields and the technical limits of drilling reach, the geographic spread of the bottom-hole locations will be such that it will not be possible to reach them all from a single drill center. The Project will therefore use six drill centers, each having manifolds for production and injection. The location of each

[26] A condition arising in oil wells and flowline risers, characterized by an intermittent two-phase flow regime (elongated bubbles of gas, separated by slugs of liquid)

manifold will be selected to minimize overall length of the drilling well paths (from seabed to bottom-hole) and hence minimize drilling cost, while also ensuring the well paths avoid shallow hazards and do not exceed the limits of drilling complexity.

There will be seven to ten producers/injectors at each drill center as part of the base development. However, provision has been made for four to five additional producers/injectors at each drill center to account for in-fill drilling[27] to improve overall recovery in the future. Attempting to include all producers/injectors into single production/injection manifolds would have result in very large subsea structures. Instead, each drill center will have two production manifolds and two injection manifolds. To improve execution efficiency, all the production manifolds are the same (six-slot), as are the injection manifolds (also six-slot). Furthermore, the Project production manifolds will be identical to those for the Liza Phase 1, Liza Phase 2, and Payara projects, which will further improve design and execution efficiencies.

The manifolds will be tied back to the FPSO by flowlines, pipelines, and risers. Routing of flowlines/pipelines/risers between the manifolds and FPSO primarily seeks to minimize overall length while also avoiding clashing (e.g., between risers, umbilicals, and mooring lines). Minimizing length not only minimizes Project cost but also Project footprint (and environmental impact).

With respect to onshore components of the Project, the preferred alternative from an environmental perspective is to use existing shorebases in Georgetown with sufficient capacity to meet Project needs. If additional shorebases are developed in the future by third parties through separate permitting processes, EEPGL will consider the potential benefits (environmental, technical, and economic) of using these shorebases in addition to or in lieu of the shorebases that currently exist.

2.18.2. Development Concept Alternatives

This section describes the following types of major development concept alternatives considered:

- Drilling facility alternatives
- Production facility alternatives
- Crude offloading alternatives
- Associated gas management alternatives
- Produced water management alternatives

2.18.2.1. Drilling Facility Alternatives

The primary alternatives considered for development well drilling included a drill ship and a semi-submersible drilling rig. Drill ships allow for more efficient development operations as compared to semi-submersibles, given their increased variable deck load—which is critical due

[27] The addition of wells in a field that decreases average well spacing. This practice can both accelerate expected recovery and increase estimated ultimate recovery in reservoirs by improving the continuity between injectors and producers. As well spacing is decreased, the shifting well patterns can alter the formation-fluid flow paths and increase access to areas where greater hydrocarbon saturations exist.

to multi-well drilling and completion equipment requirements. Drill ships also allow for faster transit speeds between drill centers, resulting in significant time-savings due to frequency of well movements during batch drilling[28] operations.

2.18.2.2. Production Facility Alternatives

Several different types of production facility alternatives were evaluated during the early stages of the design process. Fixed-leg platforms (facilities built on steel or concrete legs anchored directly into the seabed) are normally only found in water depth less than 500 meters (1,640 feet), so this type of design concept was screened out. Tension-leg platforms (floating facilities moored to the seabed by vertical steel tendons) can be used in greater water depths, but only up to water depths of approximately 1,500 meters (4,921 feet), so this type of design concept was also screened out. For water depths greater than 1,500 meters (4,921 feet), offshore developments normally use a floating structure. As the water depth in the PDA is in the range of approximately 1,700 to 1,900 meters (5,577 to 6,234 feet), this left two feasible production facility alternatives for further screening: a semi-submersible structure (Figure 2.18-1) and an FPSO (Figure 2.18-2).

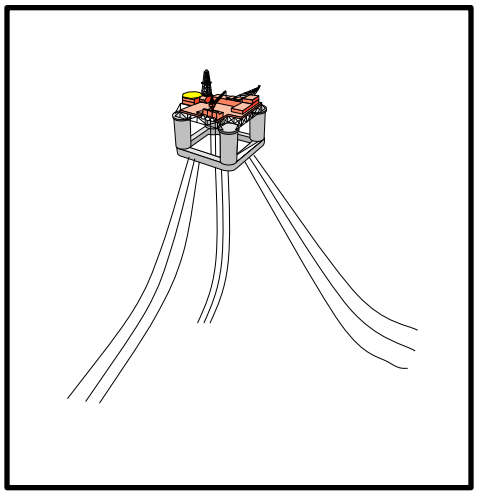


Figure 2.18-1: Semi-Submersible Platform

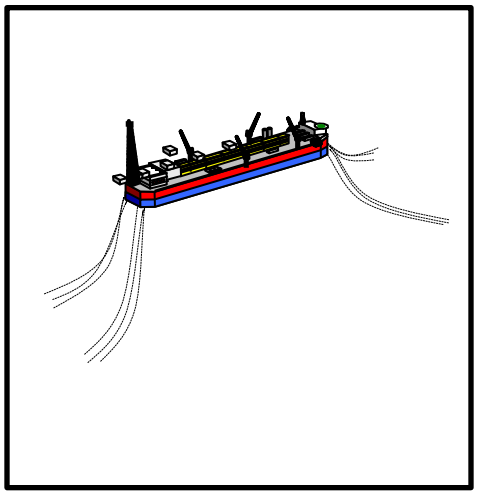


Figure 2.18-2: FPSO

Semi-submersible platforms use ballasted columns that extend below the surface of the ocean. These columns are connected to a surface deck above the water on which the production facilities are built. The columns used to support the operating platform can extend high above the wave height, allowing for semi-submersibles to operate in harsh environmental conditions. The deep draft of the vertical columns also helps to stabilize the structure. To keep the semi-submersible stationary, the columns are moored to the ocean floor with a spread-moored system.

[28] The process of drilling the same sections (e.g., top-hole sections) of multiple wells sequentially before drilling begins on the next sections.

FPSOs are typically ship- or barge-shaped, with the facilities for processing oil and gas built on the top deck and the oil stored in the vessel's cargo tanks. The two main construction methods are either converting an existing oil cargo tanker into an FPSO or building a new hull. Conversions limit the design and size of the topsides that can be integrated. New-build hulls allow for larger topsides.

There are options in the way to moor an FPSO to the seafloor. For calmer sea states, spread mooring an FPSO, as pictured on Figure 2.18-2, is common. For harsher sea states, turrets can be installed that extend from the FPSO vertically down to the sea floor. The turret can either be integrated into the hull of the FPSO or affixed externally to the FPSO and the FPSO can "weather vane" around the turret depending on the direction of the current.

Regardless of the structure, the chosen facility for the Project would need to process the same volumes of oil, gas, and water. As such, topsides facilities are similar between an FPSO and a semi-submersible. The real distinction is the need for oil storage. An FPSO has storage integrated into its facilities. A semi-submersible would require an additional floating, storage, and offloading (FSO) facility to allow for the oil storage (Figure 2.18-3). The FSO adds cost above the FPSO design and a semi-submersible with an FSO would also require additional moorings as compared to an FPSO. The use of an FSO would thus significantly increase the Project offshore infrastructure, which would increase potential Project impacts on air quality (e.g., increased air emissions), marine water quality (e.g., additional effluent discharges), marine benthos (e.g., increased disturbance of the seafloor for the FSO mooring system), and marine use and transportation (e.g., additional marine safety exclusion zones for marine vessels). For these reasons, an FPSO was selected as the preferred production facility alternative for the Project.

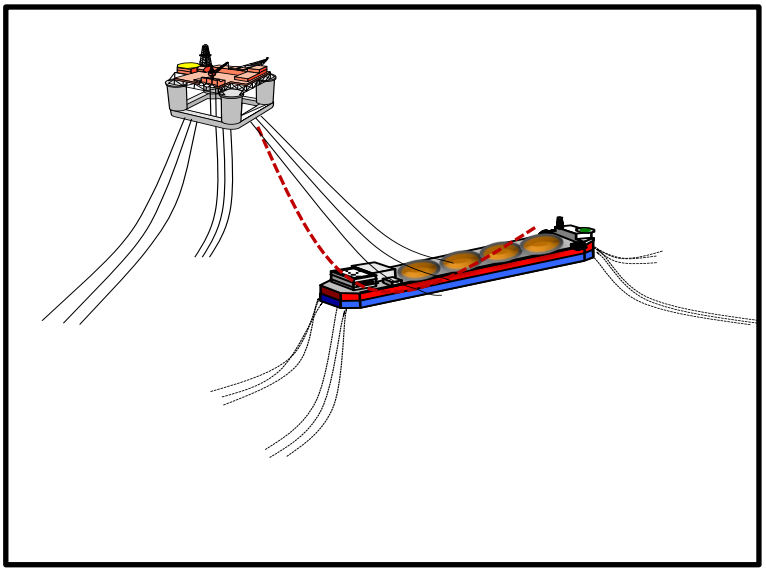


Figure 2.18-3: Semi-Submersible Platform with FSO

2.18.2.3. Crude Offloading Alternatives

With respect to commercialization of recovered crude oil, the principal alternatives for an offshore development are: (1) transmission to shore via subsea pipeline infrastructure to an onshore refining facility; and (2) offloading to export tankers for transport to onshore refining facilities located further from the resource than can be feasibly connected via pipeline infrastructure. As there are no existing petroleum refineries in Guyana or existing regional offshore pipeline infrastructure in close proximity, the only feasible alternative is offloading to export tankers for sale to existing refining facilities around the world.

During the Project design, two alternatives were evaluated for crude offloading to tankers: tandem offloading (having export tankers directly link to the FPSO for offloading) and using what is known as a catenary anchor leg mooring (CALM) buoy for offloading.

Tandem Offloading

Figure 2.18-4 shows a schematic of a tandem offloading operation. The bow of the tanker is connected to the stern of the FPSO via a hawser line. A marine hose string connects the mid-ship cargo manifold on the tanker to the stern of the FPSO for offloading of the crude oil.

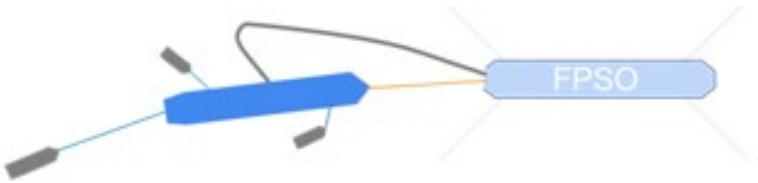


Figure 2.18-4: Schematic of Tandem Offloading from a Spread-moored FPSO

In this schematic, three tugs are connected to the tanker to keep the tanker on station during offloading. In most operations, only the single holdback tug pulling at the stern of the tanker is required. The second tug, shown pulling near the bow of the tanker, can provide additional station-keeping capacity in more demanding sea states. The third tug is on stand-by most of the time and is typically only activated in special circumstances (e.g., breakdown of other tugs, significant change of weather, etc.).

Tandem offloading of crude oil is an industry-common practice. Based on extensive desktop study and marine/bridge simulations, it was confirmed to be a suitable option for the Project, with minimal anticipated deferred production on a yearly basis during peak production period. For off-peak production periods, the anticipated deferred production rate is negligible.

To further reduce risk associated with tandem offloading, the Project has incorporated several embedded controls representing significant improvements over typical industry practice, as noted in Table 2.18-1.

Table 2.18-1: Project Embedded Controls to Reduce Risk Associated with Tandem Offloading

Parameter	Yellowtail FPSO	Industry Typical
Number of tugs	3	2
Holdback tug bollard pull capacity (ton)	120	~100
Separation distance from FPSO (meters)	120	~90
FPSO onboard metocean station	Yes	No

CALM Offloading

CALM buoy offloading has been used in the industry for many years. With the CALM buoy method, the export tanker connects to a buoy some distance from the FPSO. The advantage of a CALM buoy is that the export vessel can “weather vane” around the buoy. This allows for export of crude during harsher weather, as it allows for a larger separation distance between the FPSO and the tanker (typically a few hundred meters). Figure 2.18-5 is a schematic of a CALM buoy offloading operation.

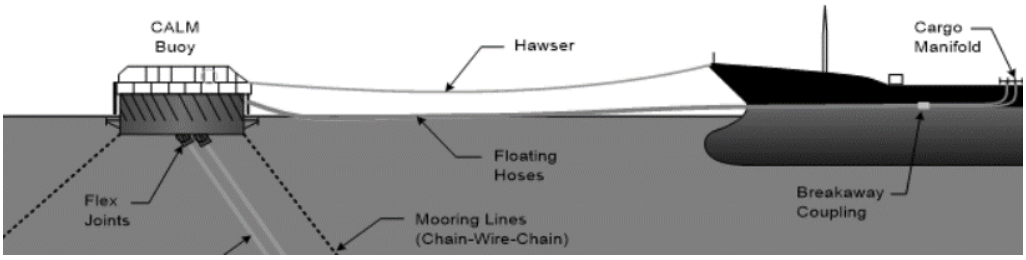


Figure 2.18-5: Schematic of Oil Offloading from a Deepwater CALM Buoy

Use of a CALM buoy for the Project faces a few key challenges due to the unique site-specific environments in the PDA:

- Site-specific currents—The deep current environment (with relatively high-speed currents from surface all the way down to 1,000+ meter [3,280+ foot] depth, and with sometimes current direction reversal at depth versus at the surface) would pose significant challenges to a flowline from the FPSO to the CALM buoy, possibly requiring risers and deep submerged/subsea flow lines that would significantly increase the complexity and cost of the CALM buoy solution.
- Water depth—The PDA has a water depth of between approximately 1,700 and 1,900 meters (5,577 and 6,234 feet). Typically, the industry employs deepwater CALM buoys in water depths of 1,000 meters (3,280 feet) or less. The much deeper water depth would require larger/stronger mooring system, which in turn may require a larger CALM buoy to provide sufficient buoyance for the mooring system.
- Footprint—A CALM buoy would increase the Project's environmental footprint relative to tandem offloading. The CALM buoy may be moored in a similar top chain (polyester rope) bottom chain—pile configuration as that of the FPSO. To provide sufficient station-keeping capability to the CALM buoy, a nine-line mooring system (i.e., three groups of three configuration) could be required, which would bring the additional mooring footprint to a level at the same order as the footprint for the FPSO mooring system.
- Piles—For each additional mooring line, a seabed pile will be required. The large dynamic motion of the CALM buoy may lead to concerns related to potential pile trenching. CALM buoy pile trenching is a greater concern than for FPSO mooring piles, where the dynamic motion of the FPSO is much smaller.
- Cost—Overall, the additional cost associated with a CALM buoy does not justify the savings associated with the minimal anticipated deferred production for the tandem offloading option during the peak production period.

Based on the considerations noted above, tandem offloading was selected as the preferred crude offloading alternative.

2.18.2.4. Associated Gas Management Alternatives

The Yellowtail and Redtail fields contain material quantities of associated gas. A key use for this associated gas is for use as fuel in gas turbines for power generation on the FPSO. Gas not used as fuel is then available for alternative uses. The three primary alternatives considered for use of associated gas include flaring, re-injection, and export.

Routine flaring of associated gas is a method to deal with natural gas production in oil developments, but introduces significant environmental considerations and would not meet regulatory expectations in Guyana nor be consistent with good international oilfield practice. Subsurface studies indicated significant value in gas re-injection for reservoir pressure maintenance and recovery uplift purposes, thus supporting related facilities investment.

From a facilities perspective, given the relatively high pressure of the Yellowtail and Redtail fields, the gas compression required for re-injection is considerable (expected to be no more than 8,200 pounds per square inch gauge, as measured at the top of the gas injection risers on the FPSO). EEPGL worked extensively with leading gas compression contractors on studies that ultimately confirmed the technical feasibility of re-injecting gas into the Yellowtail and Redtail fields.

From a subsurface perspective, it was important to assess the implications of gas re-injection on reservoir recovery. A key concern was that re-injected gas would be immiscible (i.e., with a tendency to remain separated from the liquid phase in the reservoir) and therefore move quickly through the reservoir back to the production wells, resulting in significant gas cycling, with considerable negative implications for oil production. However, subsurface studies established that the associated gas in the Yellowtail and Redtail fields is miscible with the reservoir fluid for several of the developed reservoir segments. This not only reduces gas cycling, but it also means that use of gas re-injection—particularly as part of a water-alternating-gas strategy—results in considerable uplift in recovery.

Gas export options were also considered. There is currently a separate project being proposed to transport a portion of the gas (on the order of 50 MMscfd) from the Liza Phase 1 and Liza Phase 2 FPSOs to shore, where it would be used to generate power in a gas-fired power plant. As this project would satisfy the currently identified gas demand in Guyana, there is not enough additional demand in Guyana to consume the quantities of associated gas that will be produced from the Project (expected to peak at around 450 MMscfd). A decision with respect to the export of gas from the Yellowtail Project will be made in the future; gas export to shore or another phase of field development may be considered. Space reservation and basic design connections to allow for this are included in the Project scope.

Gas re-injection was ultimately selected for associated gas management due to the additional oil recovery it provides, the environmental advantage it represents as compared to flaring, and the limited availability of feasible gas export options. However, while gas re-injection is the preferred alternative for associated gas management, it is recognized that future gas export options may become available. While gas export facilities would not be initially installed on the Yellowtail FPSO due to the strategy to maximize gas re-injection, they can be added if future gas export from Yellowtail is pursued. Any future gas export would be considered a separate project.

2.18.2.5. Produced Water Management Alternatives

The petroleum reservoirs discovered in the Stabroek Block contain water that naturally co-exists with the hydrocarbon deposits prior to any development of the resource. As production of hydrocarbons progresses and the saturation of hydrocarbons in the reservoir matrix decreases, this water, referred to as *connate water*, will be recovered from producing wells along with the oil and natural gas. The connate water from the various producing reservoirs in the Liza Phase 1, Liza Phase 2, Payara, and Yellowtail Development Projects has been sampled as part of formation evaluation activities and analyzed for concentrations of inorganic and organic

substances. The results from the analyses of connate water from the Yellowtail and Redtail fields are summarized in Table 2.18-2.

Table 2.18-2: Connate Water Analytical Results from Yellowtail and Redtail Fields Producing Reservoirs

Ions		Yellowtail-4B	Yellowtail-2A	Redtail
		(mg/L)	(mg/L)	(mg/L)
Barium	Ba^{+2}	19	1.2	25
Calcium	Ca^{+2}	285	215	265
Magnesium	Mg^{+2}	38	18	34
Potassium	K^{+}	100	66	105
Silicon	Si^{+4}	35	74	42
Sodium	Na^{+}	8,670	5,890	8,360
Strontium	Sr^{+2}	20	20	21
Alkalinity (as Bicarbonate)	HCO_3^{-}	3,930	4,550	3,130
Borate	$B(OH)_4^{-}$	94	175	150
Bromide	Br^{-}	52	48	55
Chloride	Cl^{-}	11,200	6,850	11,070
Sulfate	SO_4^{-2}	52	62	32
Bicarbonate	HCO_3^{-}	1,541	507	457
Acetate	CH_3COO^{-}	3,010	2,630	2,410
Butyrate	$CH_3(CH_2)_2CO_2^{-}$	52	93	54
Glycolate	CH_2OHCOO^{-}	<5.0	<5.0	<5.0
Propionate	$CH_3CH_2CO_2^{-}$	220	280	210
Valerate	$CH_3(CH_2)_3CO_2^{-}$	14	23	17

Laboratory testing of Guyana produced water and water chemistry modeling demonstrated a tendency to form scale. To mitigate the risk of scale formation in the production facilities, scale inhibitor will be injected into the producing wells.

Additionally, to increase oil recovery, treated seawater will be injected into the oil reservoirs to refill the voidage created by the removal of oil and natural gas and to help direct oil to the producing wells. The presence of sulfate ions in the seawater, in combination with high concentrations of barium or strontium often found in reservoir connate water, is a source of potential scale formation in the reservoir that could reduce seawater injectivity over the life of the field. To prevent this scale formation at the seawater injection wells, a seawater treatment membrane filtration treatment process is used to reduce the amount of sulfate ions in the seawater before it is injected into the reservoir. In addition, the removal of sulfate ions in the seawater also minimizes potential for H_2S generation in the reservoir. Ultimately, this injected seawater will be cycled through the reservoir and also recovered from producing wells along with the oil and natural gas. The properties of the untreated and treated seawater are summarized Table 2.18-3.

Table 2.18-3: Properties of Untreated and Treated Seawater

Ions		Untreated Seawater (mg/L)	Treated Seawater (mg/L)
Potassium	K^+	432	424
Sodium	Na^+	11,300	11,080
Magnesium	Mg^{+2}	1370	76.6
Calcium	Ca^{+2}	475	136
Strontium	Sr^{+2}	7.9	1.11
Barium	Ba^{+2}	0.1	0.0
Carbonate	CO_3^{-2}	16.2	6.8
Bicarbonate	HCO_3^-	151	115
Nitrate	NO_3^-	0.2	0.2
Chloride	Cl^-	19,551	17,826
Sulfate	SO_4^{-2}	2,840	40

The combination of the connate water and cycled treated seawater recovered from the producing wells is referred to as produced water. To allow for the economic recovery of hydrocarbon resources, produced water must be handled effectively and efficiently, as the volumes of produced water can be significant. For EEPGL's proposed developments in the Stabroek Block, four options were considered for the disposition of produced water:

1. Treat produced water onboard the FPSO and discharge treated produced water overboard at the FPSO location;
2. Treat produced water onboard the FPSO and re-inject the treated produced water mixed with treated seawater into the oil producing reservoir(s);
3. Dispose of produced water into suitable offshore disposal wells; and
4. Export produced water to shore for reuse or disposal after proper treatment.

For the first option, the proposed treatment process would involve a three-phase (oil-water-natural gas) separator, a produced water flash vessel, a hydrocyclone, and an Induced Gas Flotation vessel. The objective of this process would be to provide a reliable method to facilitate produced water discharge overboard that does not negatively impact the environment. The option also includes mitigating controls to monitor for compliance with applicable standards for discharge water quality and to prompt remedial action by operations personnel in the event of a process upset.

For the second option, following an initial treatment process similar to the first option, the treated produced water would be further filtered for the recovery of fine solids, then mixed with treated seawater needed to support oil recovery and pumped at a pressure suitable for injection into the reservoir via a subsea flowline system. The mixture of produced water and treated seawater would then be injected into the producing formation(s) through injection wells. The objective of this process would be to provide a reliable outlet for produced water and to inject the total volume of water needed to optimize the recovery of oil.

For the third option, following an initial treatment process similar to the first option, the treated produced water would be further filtered for the recovery of fine solids and then pumped in a dedicated pumping system to a pressure suitable for injection into dedicated disposal wells via a dedicated subsea flowline system. The objective of this process would be to store the produced water in a non-oil-producing geologic formation in a method designed to avoid leakage of the produced water to the seabed or to shallow confined aquifers.

For the fourth option, produced water would be pumped to a pressure suitable for transmission to the Guyana shoreline via a subsea and onshore pipeline system. Once onshore, the water would be treated in a facility for reuse or disposal using a process similar to the first option. If disposal were chosen, the treated produced water would then be pumped to a pressure suitable for injection into onshore disposal wells or discharged to an alternative waterbody. As no feasible reuse of the treated produced water has been identified, the objective of this process would be to store the produced water in an onshore geologic formation in a method designed to avoid leakage of the produced water to the surface or to shallow confined aquifers, or to prepare it for discharge to an alternative waterbody.

While considered, options 3 and 4 ultimately were ruled out as potential best alternatives. This conclusion was reached for the following reasons:

- Option 3 is less favorable considering environmental impacts and economic feasibility as compared to option 2. Option 3 requires the installation of dedicated facilities for disposal of produced water and therefore has increased potential for environmental impacts due to dedicated disposal wells and facilities that are not required by option 2. The capital and operating costs of the dedicated disposal system and wells would be directly additive to those with option 2, yielding option 3 a less cost-efficient option. Because both the environmental and economic considerations of option 2 are more favorable than those of option 3, option 3 was ruled out as a best alternative.
- Option 4 creates the greatest potential impacts of all the options by bringing the produced water nearshore or onshore for disposal. Disposing the treated produced water into an onshore geologic formation, not known to exist as of today, or disposing the produced water in an alternative waterbody or in the nearshore area has increased potential for environmental impacts as compared to the discharge of treated produced water approximately 203 kilometers (126 miles) offshore at the FPSO location. The option to transport the water onshore would also be less cost-efficient than either option 1 or 2 due to the costs to construct and operate the pumping and pipeline system to shore. EEPGL is not aware of any locations where deepwater oil production operations at a similar distance to shore are currently using this technique.

The analysis of the options 1 and 2 has therefore been performed at a higher level of detail and is further described below.

Comparison of Overboard Discharge and Re-injection of Produced Water Options

Option 1, involving the overboard discharge of treated produced water at the FPSO location, is a common practice for deepwater oil and gas operations applied at many locations in the world.

The proposed treatment process includes a three-phase (oil-water-natural gas) separator, a produced water flash vessel, a hydrocyclone, and an Induced Gas Flotation vessel. This system provides the following benefits:

- The system is capable of treating the produced water to a quality that meets or exceeds published standards for discharged water quality from the World Bank Group, the U.S. Environmental Protection Agency (USEPA), and the Convention for the Protection of the Marine Environment of the North-East Atlantic (also referred to as the OSPAR Convention). The system also includes mitigating controls to monitor compliance with applicable standards for discharge water quality and to prompt remedial action by operations personnel in the event of a process upset.
- The system is highly reliable. As the components in the system are primarily static equipment, the system has been assessed to be more reliable than other identified alternatives. Additionally, with the produced water overboard discharge, there is no linkage to the availability of downstream water injection filtration, pumping, or injection wells. As part of the FPSO production system, high availability of the produced water disposition system is needed to support the FPSO production system availability targets.
- The system is efficient from a capital and operating cost perspective. Because the components of the system are primarily static equipment, have a relatively small size and weight, and require relatively infrequent intervention, the system is economically attractive versus other options for produced water disposition.

The potential downsides to overboard discharge of produced water at the FPSO location include:

- Potential environmental impact. The discharge has been assessed to have Negligible environmental impact due to the limited area near the discharge point that is impacted. Modeling using the Cornell Mixing Zone Expert System (CORMIX) dilution model (a method approved by the USEPA), at a distance of 100 meters (328 feet) from the discharge point, shows the thermal impact of discharging the produced water is predicted to be less than 3°C (5.4°F) above the ambient sea temperature (a guideline from the World Bank offshore oil and gas development guidelines [World Bank 2015]). Additionally, concentrations of oil and grease and production-related water treatment chemicals at a distance of 100 meters (328 feet) from the discharge point are predicted to be 98.2 percent below discharge levels, indicating that mixing and dilution in the environment further reduce environmental impact.
- Process upsets can affect the overboard water quality, although this is mitigated by automated monitoring of the overboard water quality. When off-specification water is identified, the off-specification produced water is redirected to an approximately 9,500 m^3 (335,489 cubic foot) holding tank, where large residence times are available to further separate the oil from the water before water is discharged overboard. Alternatively, after the process has been stabilized, the water can be re-routed back to the produced water treatment facility from the holding tank for further processing before being discharged

overboard. If the overboard water quality remains above specification as the holding tank fills, production from the wells to the FPSO would be stopped.

Detailed discussion of the components proposed as part of the produced water treatment system for overboard discharge is presented in Section 2.18.3.5, Produced Water Treatment.

Option 2, involving re-injection of the treated produced water into the oil producing reservoir(s), is frequently used in onshore and shallow-water offshore oil and gas operations, but is less frequently used in deepwater oil and gas operations. For this option, following an initial treatment process similar to the option 1, the treated produced water would be further filtered for the recovery of fine suspended solids, then mixed with treated seawater needed to support oil recovery and pumped to a pressure suitable for injection into the reservoir via a subsea flowline system. The mixture of produced water and treated seawater would then be injected into the oil producing reservoir(s) through injection wells. This system provides the following benefits:

- This system would minimize the discharge of treated produced water to the environment, noting that the discharge has been assessed to have Negligible environmental impact due to the limited area near the discharge point that is impacted.
- This system would reduce seawater treatment demand during later stages of the Project. However, this benefit cannot be realized for the initial production years where water injection demand is high but produced water volumes are low. Hence, the water treatment system design capacity does not benefit from produced water re-injection.

EEPGL reviewed operating experience where up to 100 percent produced water reinjection (PWRI) has been applied in similar assets, including assets that are not owned by EEPGL (or affiliates) to understand the challenges associated with PWRI. PWRI is often used in onshore applications for reservoir management because of limited water availability and relatively inexpensive remediation costs. Key aspects and learnings for offshore deepwater application, including potential downsides associated with PWRI, are summarized in Table 2.18-4.

Table 2.18-4: Industry Experience Key Learnings and Considerations

Topic	Learnings
Injection Regime	• Most of the industry's PWRI wells are operated above sand fracture pressure (and below shale fracture pressure). Typically, sand fracture pressure is exceeded in early well life (Abou-Sayed et al. 2005; Hagan et al. 2002). • Operating above the shale fracture pressure (which is typically significantly higher than sand fracture pressure) can lead to out-of-zone injection. Active surveillance is needed to manage this out-of-zone injection.
Water Quality	• Due to lower water quality, PWRI accelerates the rate of decline in injectivity (Paige et al. 1995; Tipura et al. 2013; Abou-Sayed et al. 2007; Onaisis et al. 2011; Abou-Sayed et al. 2005; Hagan et al. 2002; Mainguy et al. 2020). Solids and oil-in-water content, which are higher in PWRI, will greatly influence the rate of decline. • Regardless of quality at the surface, water quality tends to worsen as water passes down-hole due to corrosion and scaling. Facility upsets and regular maintenance can also contribute to a substantial decrease in water quality for short durations. • Increased solids content in the injected fluids is known to cause choke erosion, potentially affecting the ability to control individual injection rates and bottom-hole

Topic	Learnings
	pressure, affecting the ability to optimize sweep and maximize recovery (Mainguy et al. 2020). • During PWRI facility upsets, produced water is typically treated to overboard quality specifications and discharged to sea (Zuluaga et al. 2011).
Remediation	• PWRI is known to lead to expensive and short-lived remedial efforts to stay below shale fracture pressure (Dumas et al. 2018). Much more frequent stimulation would be needed to stay below sand fracture pressure and may not be feasible in practice. • Techniques employed in industry applications of PWRI to prolong the well life include the following: – Inject above sand fracture pressure and below shale fracture pressure. – Maintain high water quality for injected fluids. – If cost effective, pursue remedial efforts such as injector stimulations, choke replacements, and/or re-drills.
Risk Management	• Mixing of produced water and seawater is known to lead to the following: – Elevated solids content due to scaling (Zuluaga et al. 2011; Paige et al. 1995; Mackay et al. 2003), which can damage the completion. Scale risk is managed through pigging, chemical injection / stimulations, and studying the compatibility of produced and injected fluids. – For reservoir souring (Zuluaga et al. 2011; Evans et al. 2015), operator opinion varies on the effectiveness of biocides to mitigate reservoir souring.

PWRI feasibility studies conducted on a previous Guyana project identified several risks associated with PWRI which would also apply for the Yellowtail Project, including:

- Short matrix injection lifetime predicted for PWRI injection wells;
- Increased environmental impact from additional waste management from produced water filtration and GHG and other atmospheric emissions from operating PWRI equipment and well intervention activities needed to try to maintain injectivity targets;
- Increased reservoir souring potential;
- Increased scaling potential when injecting produced water into the formation (mitigation relies on successful continuous inhibition, typically involving expensive remediation options for barite and iron sulfide scales);
- Increased chance of subsea well choke and tree replacements due to erosion caused by solids in produced water; and
- Significant increase in life cycle cost driven by offshore well intervention activities.

The potential for scale risk formation resulting from re-injection of produced water is discussed further below.

Scale Risk Formation: Injection of Produced Water Mixed with Seawater versus Injection of Only Seawater

The following is a discussion of the potential for scale formation associated with injection of treated seawater versus the injection of a mixture of treated seawater and produced water. The discussion below is presented in two parts, corresponding to the types of scale that can result from this process (i.e., sulfate scale and carbonate scale).

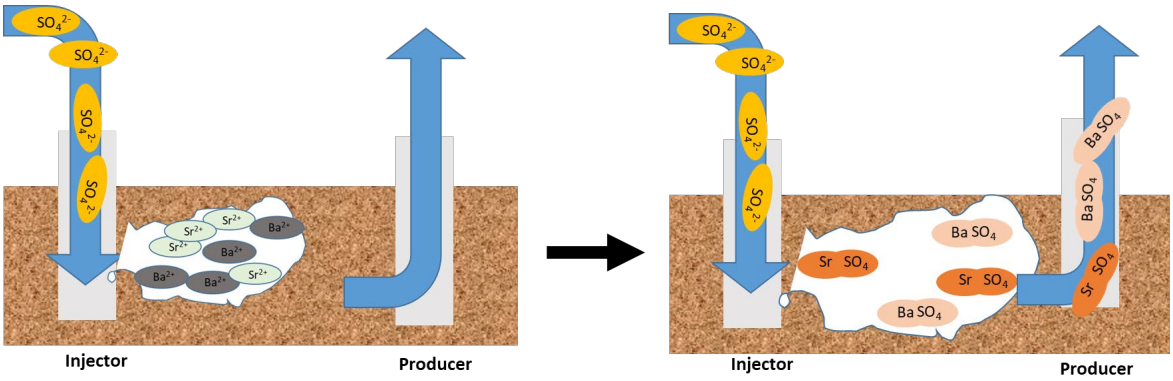
Sulfate Scale ($BaSO_4$ and $SrSO_4$) Formation in Injection of Treated Seawater versus Injection of Mixture of Treated Seawater and Produced Water

The chemical reactions relevant to the discussion presented below include the following:

$$Ba^{2+} + SO_4^{2+} \leftrightharpoons BaSO_4\ (barium\ sulfate)$$

$$Sr^{2+} + SO_4^{2+} \leftrightharpoons SrSO_4\ (strontium\ sulfate)$$

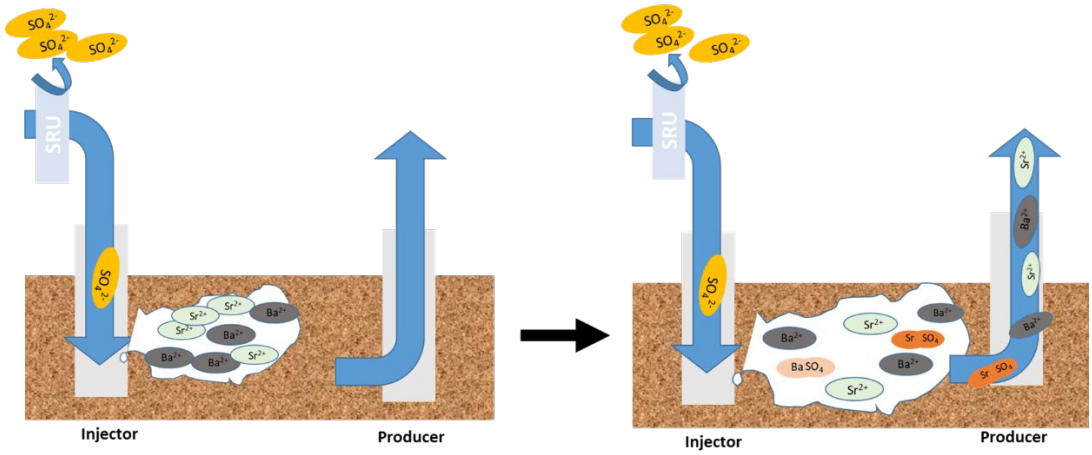
Due to the high sulfate content in the seawater and the high barium and strontium content in the formation water, these waters are not compatible in terms of barite and strontium sulfate scale risk (this was assessed with the commercial software OLI or ScaleSoftPitzer). As a result, upon injection of seawater, sulfate scale is expected to form in the reservoir through the producing wells and to the FPSO topside facilities (Figure 2.18-6).



When untreated seawater containing high sulfate levels mixes with the formation water containing barium and strontium, it is expected to form scale that is predicted to deposit in the FPSO topsides and upstream of the wellhead. Only the water phase is depicted in the above diagram.

Figure 2.18-6: Injection of Untreated Seawater and Effects on Sulfate Scale

The incompatibility of formation water with seawater and the resulting scale risk will be mitigated by treating seawater with sulfate removal units (SRUs). This technology is proven to decrease the sulfate concentration in the seawater to a minimum (Bezerra et al. 2013) (Figure 2.18-7).

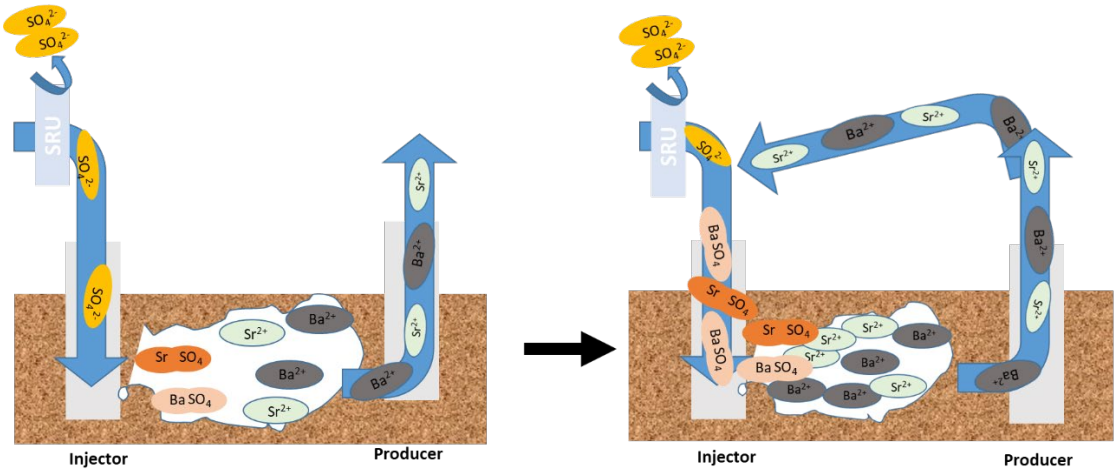


The SRUs will reduce the concentration of sulfate in the seawater to a minimal level, decreasing the risk of sulfate scale in the reservoir and producing wells and upstream of the producing wells. The minimal amount of sulfate scale that could form at the injection wells is not expected to pose a scaling risk due to the low concentration of sulfate. Only the water phase is depicted in the above diagram.

Figure 2.18-7: Injection of Treated Seawater with Sulfate Removal Units and Resultant Effect on Sulfate Scale Formation

Even though the sulfate concentration in seawater treated with SRUs is minimal, a small amount of scale could be formed if it mixes with formation water containing barium and strontium (downstream of the injection well). The risk of this sulfate scale forming in the producing wells and on the FPSO topsides is deemed to be low, based on concentration and on thermodynamic potential (Kan and Tomson 2010). To further address this low risk of sulfate scale, scale inhibitor could be injected in the producing wells. As for the risk of sulfate scale forming in the injection wells and the reservoir during injection of treated seawater, the risk is also low—not only due to the amount but also due to the massive flow area in the reservoir. This flow is expected to accommodate the small amount of scale formed near the well bore with no loss of pressure maintenance.

Produced water is expected to contain barium and strontium from the formation water. If the produced water containing these ions were to be mixed with the treated seawater (containing minimum levels of sulfate) prior to injection, scale will be formed through the injection system affecting operations. These solids can also result in injectivity decline over time as they deposit in the injector (Figure 2.18-8) (Bedrikovetsky et al. 2006).



The reduced sulfate concentration in the treated seawater will react with the barium and strontium present in the produced water, forming scale that can deposit through the injection system or in the injector.

Figure 2.18-8: Injection of Mixture of Treated Seawater with Produced Water and Resultant Effect on Sulfate Scale Formation

Declines in injectivity can directly and negatively impact production rates of paired or associated producing wells. Although potential remediation of injecting wells with decreased injectivity due to sulfate scale can be achieved with mechanical removal, it is very challenging operationally and might not completely re-establish injection. Likewise, managing the low scaling risk in injecting wells with a combination of scale inhibitor and fracture injection does not guarantee that the risk will be completely mitigated (Zuluga et al. 2011). Thus, the optimal approach to facilitate continuity of injectivity and production is prevention of sulfate scale by installing SRUs to treat the seawater and avoiding injection of produced water.

Carbonate Scale ($CaCO_3$ and $SrCO_3$) in Injection of Treated Seawater versus Injection of Mixture of Treated Seawater and Produced Water

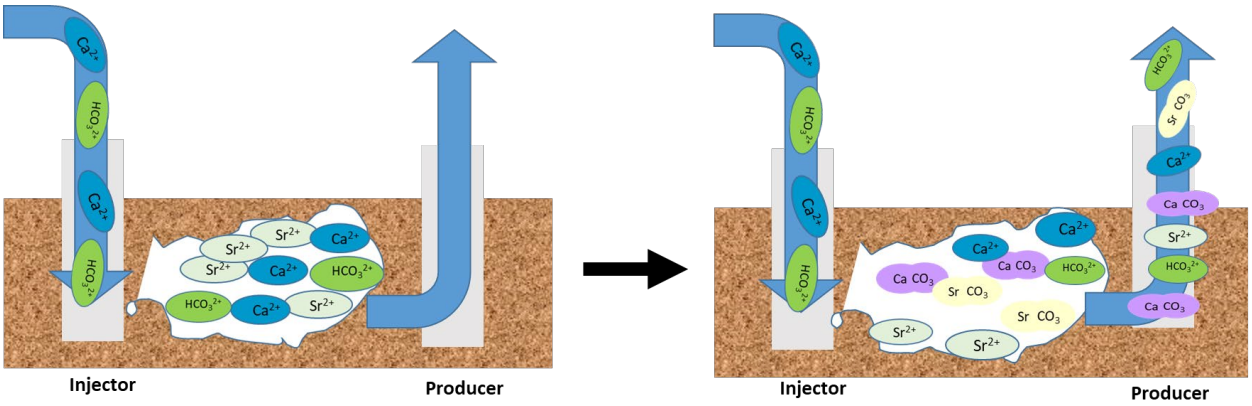
The chemical reactions relevant to the discussion presented below include the following:

$$Ca^{2+} + 2HCO_3^{2-} \leftrightharpoons CaCO_3 + H_2O + CO_{2(g)} \uparrow (calcium\ carbonate)$$

$$Sr^{2+} + 2HCO_3^{2-} \leftrightharpoons SrCO_3 + H_2O + CO_{2(g)} \uparrow (strontium\ carbonate)$$

Carbonate scale formation, as shown in the equations above, is largely driven by changes in pressure and also temperature. A reduction in pressure causes the dissolved carbon dioxide (CO_2), present as carbonate when dissolved in water, to escape the water as a gas. This removal of CO_2 shifts the chemical equilibrium toward the right, increasing calcite or strontium carbonate precipitation.

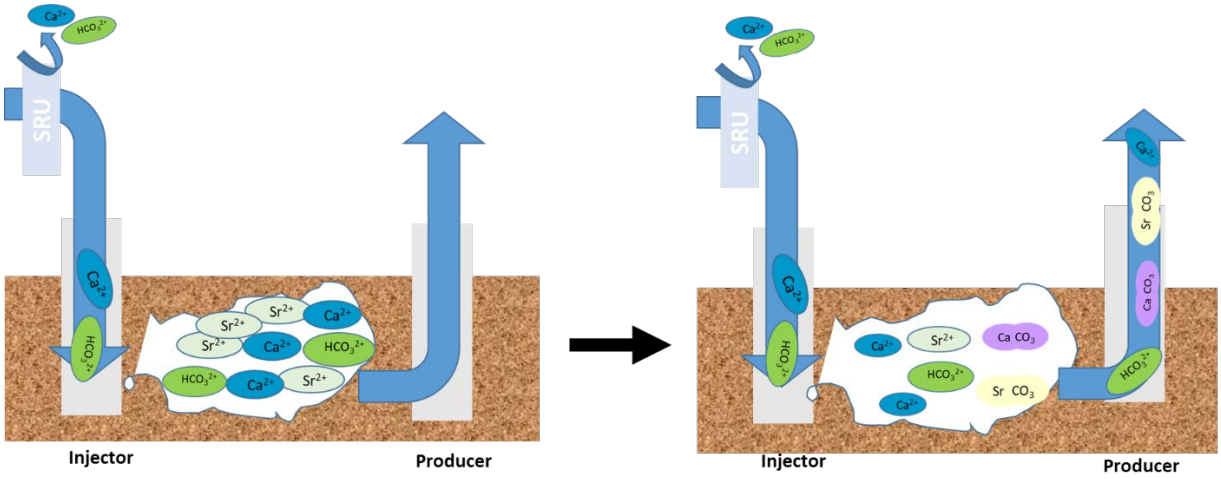
Based on ion concentration, pressure, and temperature downhole, carbonate scale risk for mixing of untreated seawater with formation seawater was estimated to be low from the reservoir through the producing wells and to the topside facilities. Even though the risk is low, injection of scale inhibitor in the producing wells can be performed if the risk needs to be addressed (Figure 2.18-9).



Injection of untreated seawater poses a low risk for carbonate scale.

Figure 2.18-9: Injection of Untreated Seawater and Resultant Effect on Carbonate Scale Formation

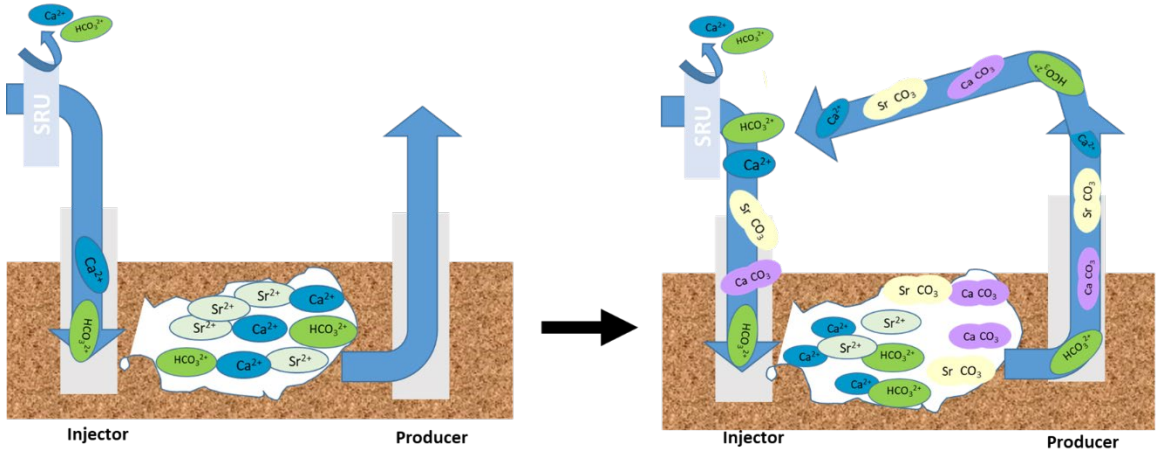
In the case of injection of SRU-treated seawater, SRUs provide the advantage of also reducing concentration of calcium, strontium, and bicarbonate, potentially lowering the carbonate scale risk compared to the risk of injection of untreated seawater (Figure 2.18-10).



Injection of treated seawater is expected to further reduce risk of carbonate scale.

Figure 2.18-10: Injection of Treated Seawater with Sulfate Removal Units and Resultant Effect on Carbonate Scale

Produced water is expected to contain calcium and bicarbonate from the formation water. If this produced water were to be mixed with treated seawater containing these ions (although at a low concentration), carbonate precipitation risk could increase due to the overall higher concentration of ions in the mixture. These scale particles could then be carried into the injection well, potentially affecting injectivity (Figure 2.18-11).



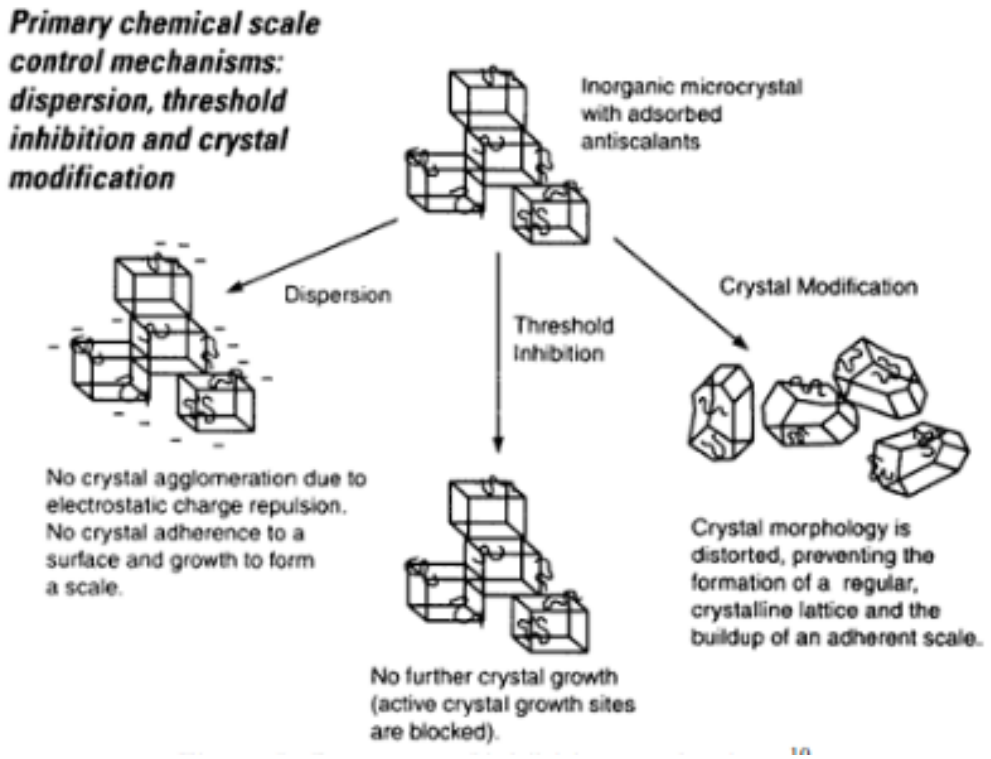
The reduced sulfate concentration in the treated seawater will react with the barium and strontium present in the produced water, forming scale that can deposit through the injection system or in the injector.

Figure 2.18-11: Injection of Mixture of Treated Seawater with Produced Water and Resultant Effect on Carbonate Scale

Although remediation of injectivity decline due to carbonate scale can be achieved with chemical treatment (e.g., acid injection), this procedure still requires injection well downtime, which can in turn impact production rates. Avoiding injection of produced water is the optimal approach to prevent injectivity decline and injection well downtime (Mainguy et al. 2020).

Scale Inhibitor to Address Low Risk of Sulfate Scale with Treated Seawater

Scale inhibitors are chemicals that prevent the deposition of scale in surfaces by inhibiting or slowing down nucleation (initiation of crystal growth) and crystal growth. The proposed general mechanism of action is that the anionic chemical groups present in the polymer chain can attach to the cations (2+) in the surface of the scale, inhibiting aggregation of scale particles and crystal growth (Kelland 2009; Liu et al. 2012) (Figure 2.18-12).



Source: Liu et al. 2012

Figure2.18-12: Summary of Inhibition Mechanisms by Scale

A type of scale inhibitor that can be used for the management of scales is a sulfonated carboxylic acid polymer. Both sulfonate ($-SO_3^-$) and carboxylic ($-CO_2^-$) moieties present in this type of polymer can interact with the divalent cations on the surface of the scale, preventing more solids aggregation and deposition. If during injection of treated seawater the low sulfate scale risk in the producing wells and topsides needs to be addressed, scale inhibitor could be injected in the producer to prevent scale formation.

Summary

The potential downsides to the PWRI into the oil production reservoir(s) include the following:

- Industry experience demonstrates that re-injection of produced water can result in the loss of injection capacity of injection wells at matrix injection pressures. A common cause for the reduction in injectivity includes the deposition of fine suspended solids (from the reservoir or precipitate scale) at the reservoir face in injection wells. The loss of injectivity can result in failure to achieve the needed water injection to optimize oil recovery.
- ExxonMobil's global experience indicates that the mixing of produced water and seawater increases the probability of scale formation in the injection system that could cause well injectivity losses. Additional laboratory testing would be required to determine what scale inhibition/mitigation might be required to manage the risk of mixing the produced water and treated seawater in option 2.

- To mitigate the risk of injectivity loss, the produced water treatment process from option 1 must be enhanced to also include micro- or ultra-filtration units that would likely target capture of particles above 3 µm in diameter. These units would be required due to the small pore throat size of the reservoir rocks (41 percent of the Yellowtail reservoir pore throats are under 20 µm in diameter) as compared to the size of particles that can pass the produced water treatment system described in option 1. Even with these filters, during a filter upset condition (such as a filter element internal failure), fine suspended solids could pass to the injection wells and decrease injectivity. These filter units are also expensive to operate and have lower availability due to frequent filter backwashing or filter change requirements.
- Discharge of treated produced water to the environment would still be required in association with upsets or maintenance in the water filtration, pumping, flowlines, or injection wells to maintain the same FPSO production system availability. If discharge were not allowed for upsets on the filtration, pumping, injection flowlines, or injection wells, the availability of the FPSO production system would decrease and would put the FPSO availability target at risk.
- In the event of a loss of well-injectivity, technical and economic analysis would have to be performed to determine the best option to address the injection capacity loss. Options could include the drilling of a replacement injection well, remedial well work to attempt to remove the materials that are reducing injectivity, or doing nothing and accepting the loss of otherwise recoverable resources. The cost/value loss of these options is on the order of millions to hundreds of millions of U.S. dollars.
- If drilling of a replacement injection well or remedial well work was selected as the option to deal with injection capacity loss, there would be incremental environmental impacts and exposure associated with the drilling and/or well work operations. Well work options would likely result in recovery of fine suspended solids, which would require waste management.
- Option 2 is economically inferior as compared to option 1. This results from the potential to reduce oil recovery due to injectivity impacts, potential costs to drill replacement injection wells or perform remedial well work on injection wells with injectivity loss, potential decreased FPSO production system availability due to filter maintenance, and the incremental capital and operating costs associated with the micro- or ultra-filtration units that would be required.

Based on the many supporting factors for option 1 and the numerous potential downsides with option 2, overboard discharge of treated produced water (option one) was selected for the Project after taking into account the technical feasibility and economic evaluations with a consideration of regulatory requirements and predicted environmental impact. This selection also is consistent with good international oilfield practice (World Bank 2015).

2.18.3. Technology Alternatives

EEPGL is using the most appropriate industry-proven technologies in developing the Project, in terms of well drilling, drilling fluids, equipment selection, development concepts, and

environmental management. EEPGL's parent company, ExxonMobil, and its contractors have extensive experience in delivering offshore deepwater development projects around the world, particularly with FPSO and SURF components, and are applying that knowledge, experience, and technology in the development of this Project. EEPGL has also considered experiences in design, construction, and operation of its other development projects in Guyana and applied learnings to technology choices for the Project.

In alignment with the Guyana Environmental Protection Act Part IV: Environmental Impact Assessments, Requirement of Environmental Impact Assessment, "the developer shall have an obligation to use the most appropriate technology" and to provide a description of the BAT. This section outlines the fundamental basis of decision-making for key equipment and environmental performance criteria and what EEPGL considers BAT while taking into account technical and commercial considerations. In this respect, EEPGL has referred to the following condition from the Payara Environmental Permit when making BAT decisions for the Project:

> "The best available techniques, which consider economic and technical feasibility, as well as the facilities and controls described in the EIA, shall be used to prevent or mitigate pollution in relation to any aspect of the operation, which is not regulated by any other condition of this Permit."

EEPGL has considered the following aspects when making BAT design and operational decisions:

- Technology options and selection
- Feasibility evaluation
- Economic evaluation
- Regulatory requirements/benchmarking
- Environmental aspects and impacts

The sub-sections below describe the BAT decision process undertaken for the following technology aspects:

- Drill cuttings
- Gas processing
- Injection compressors
- Power generation
- Produced water treatment
- Seawater treatment

2.18.3.1. Drill Cuttings

Options and Techniques—Choice of Drilling Fluid

When considering the choice of drilling fluid for deepwater operations, the options are drilling with WBDF or NADF. WBDF are not commonly used in deepwater drilling. At these conditions, the WBDF experiences low-temperature conditions at the seafloor, typically less than 5°C (41°F), and high pressure from the weight of the drilling fluid (in excess of 1,500 psi). This allows ice-like crystals (so-called hydrates) to form in the presence of gas and potentially plug

the safety control devices located near the seafloor. The WBDF has to be formulated using suitable inhibitors, consisting of a combination of salt and glycols. Formulations of such WBDF have been reported in the literature, but for many operators, risk management and well safety has led to the choice to use NADF. Second to well control, borehole stability is a priority to the well construction. WBDFs, through the flow of water and chemicals into the formation, destabilize the formation over time and may lead to the loss of the wellbore through severe borehole instability. The lubricity of WBDF is low and, even with the use of lubricants, this limits the reach of development wells, requiring more drill centers to access and produce the hydrocarbon reservoirs. Some physical limitations of the WBDF such as a lower solids tolerance and a lower solids control efficiency of the rig equipment compared to NADF make the typical waste volume generated approximately twice as large as for a typical NADF.

Such limitations and risks are not present in a typical NADF. Risk mitigation leads to NADF being the most frequently used drilling fluid in deepwater operations. A properly formulated NADF does not promote the formation of ice-like crystals, and the lubricity of the NADF allows longer and higher deviation wells to access hydrocarbon reserves from fewer drill centers. A typical NADF does not invade into the formation and maintains safety through borehole stability during the drilling of well sections below the conductor casing. While the technical advantages of NADFs are undeniable, the environmental life cycle of the chosen drilling fluid also needs to be considered.

Options and Techniques—Effect of NABF

Early applications of NADF cuttings discharges using diesel and other low-refined base oils in shallow water depths showed cuttings piles in the near vicinity of the drilling location and slow recovery from the drilling impact. This led to the development of incrementally refined enhanced mineral oils and low-toxicity mineral oils. An important study by the IOGP (2003) found that the environmental impact of the discharged cuttings can be largely categorized in three groups based on the type of NABF used:

- Group I NABFs, with high aromatic content such as diesel and conventional mineral oil based fluids. These fluids have a high aromatic content (greater than 5 weight percent [wt%]) and polycyclic aromatic hydrocarbons (PAHs) greater than 0.35 wt%.
- Group II NABFs with medium aromatic content of 0.5 to 5 wt% and PAHs between 0.001 and 0.35 wt%.
- Group III NABFs, which include synthetic base oils and highly refined base oils with aromatic content less than 0.5 wt% and PAHs less than 0.001 wt%. While differences in the environmental performance between the synthetic and highly refined NABFs in Group III exist, they were not considered by the IOGP (2003) study to be significant enough to warrant a separate group classification.

A follow-up to the IOGP 2003 report 13 years later (IOGP 2016b) reviewed additional studies that investigated the effects of IOGP Group III NADF cuttings discharge. It showed that the effects on the seafloor are primarily from burial, concentrated in a 250-meter (820-foot) radius from the well site. In most studies, the recovery usually started after drilling activity was ceased,

and was often well-advanced within a year from the deposition. The effects were largely lower in water depths deeper than 600 meters (1,968.5 feet). No bioaccumulation of Group III NADF and its constituents has been reportedly observed, whereas PAHs in Group I and Group II NABFs have been reported to bioaccumulate.

Options and Techniques—Cuttings Discharge

After going through the standard solids control equipment on the rig, cuttings from borehole sections drilled with NADF contain residual drilling fluid. Additional methods are used to remove the excess drilling fluid from the cuttings and make them suitable for disposal.

The disposal method options include offshore discharge or transportation to shore for treatment and disposal. While transport to land may limit the impact offshore, transportation, emissions from transportation, treatment, and disposal onshore have an impact on the environment and require infrastructure for transportation, handling, and treatment of the cuttings.

Other approaches treat cuttings offshore by reducing the oil retained on cuttings. The NADF and NABF are selected such that the remaining NABF and additives have minimal impact on the environment. The plume from the cuttings discharge and deposited cuttings beds are modeled to assess the feasibility of discharge and potential impact. Water depth and water movement are considered in such studies. These studies are used to verify that cuttings beds that are deposited in the vicinity of the drilling location allow the benthic community to recover in a reasonable time.

Various techniques exist to treat cuttings and reduce the NABF on cuttings; the applicability of these techniques is discussed in IOGP 2016a. Of these techniques, two offshore applications are noteworthy for their ability to reduce NABF retained on cuttings: thermo-mechanical desorption and a cuttings dryer.

Thermo-mechanical desorption treatment generates large heat from friction, which in turn evaporates the fluid retained on cuttings. Using this method, the NABF retained on cuttings can be reduced to less than 1 wt%. This technically proven method requires a large space for installation on the drill ship, and may not be suitable for many drill ships without re-engineering the deck space to retrofit the equipment and buffer storage, as the real-time processing rate is less than the rate of cuttings generated in the larger boreholes. The reported rate of achievable cuttings treatment is on the order of 3.5 to 5 tonnes per hour. The significant energy consumption to generate the heat also generates additional emissions to air.

Another more commonly used technique is the use of so-called cuttings dryers. Using this method, the NABF retained on cuttings can be reduced to less than 6.9 wt%, a standard reflected in good international oilfield practice as suitable for discharge offshore [World Bank 2015]. Cuttings dryers can be readily installed on most drill ships; the hourly processing rate achievable is between 45 to 65 tonnes per hour (depending on model). Emissions and energy consumption are moderate to low, as compared to thermal-mechanical desorption.

Feasibility and Economic Evaluation

The availability of materials at a sustainable cost is an important consideration. Thermo-mechanical desorption methods are frequently applied onshore, and less often offshore. The space requirements and slower rate of treatment make it more suitable for treatment off the critical path schedule. There are several suppliers of the treatment for onshore applications; at the time of this report, there are two companies that offer offshore treatment with this method, and only one of the providers has a proven track record to reliably treat and dispose the cuttings offshore. Since its first introduction in the 1990s, the cuttings dryer technology has been proven to be a reliable technology, capable of reducing the NABF retained on cuttings in real time, as the cuttings are generated. The treatment is reliable and available from several providers.

Feasibility in terms of availability, drill ship installation, and energy consumption is also an important consideration. At superficial observation, the thermo-mechanical desorption unit appears just somewhat larger than the set-up for a cuttings dryer. However, the differentiating performance is in the energy consumption and rate of treatment. The average 3.5 to 5 tonnes per hour thermo-mechanical unit uses on the order of 950 kilowatts, whereas a conventional cuttings dyer uses less than 10 percent of this amount of energy, around 60 to 75 kilowatts. Examining the rate of treatment, average rates of cuttings generation should be considered. For example, in a typical well construction, NADF usage starts at the 17½-inch-diameter hole interval. The rate of penetration is, on average, 30 meters per hour (100 feet per hour). Assuming the wet cuttings that return have an equal amount of NADF and rock, the drilling operation generates 14 to 17 tonnes per hour. This exceeds the capacity of the thermo-mechanical unit and the excess rock plus fluid have to be stored, every hour, for the entire interval until the unit can catch up. For a length of interval of 1,500 meters (4,921 feet), it takes 50 hours to drill and requires on-site storage of 650 to 800 tonnes of cuttings because the equipment cannot keep up with the drilling progress.

Regulatory Requirements/Benchmarking

Drill ships are not considered new facilities per the World Bank Environmental, Health, and Safety (EHS) Guidelines (World Bank 2007) as they are existing equipment and are selected and contracted for global deepwater exploration, appraisal, and development drilling by multiple clients/operators as an existing commercially available vessel for such drilling operations. Use of IOGP Group III NADF, solids control, and cutting-dryer systems as used by all drill ships operating for EEPGL offshore Guyana is fully consistent with global deepwater drilling programs with a maximum residual NABF of 6.9 percent by weight wet cuttings average per well. This performance criteria is also consistent with the June 2015 World Bank Group Environmental Health and Safety Guidelines for Offshore Oil and Gas Development (World Bank 2015). This performance criterion of 6.9 percent is also consistent with multiple regulatory jurisdictions and global drilling operations across multiple countries including Guyana (via the environmental permit conditions for Liza Phase 1, Liza Phase 2, and Payara) and the United States–Gulf of Mexico (via regulations).

The use of solids control and cuttings dryer systems such as those on the drills ships currently being used in Guyana are consistently achieving an average wet weight residual NABF on cuttings of 3.5 percent per well.

Guyana does not have any specific regulations on drill cuttings discharge offshore. As such, requirements are identified, reviewed, and approved in the EIA and supporting ESMP, and it is expected that they will be further described and enforced under the final executed Environmental Permit. Therefore, EEPGL will require that drill ships use solids control and cuttings dryer systems to treat cuttings, such that, for discharged cuttings, end of well maximum weighted mass ratio averaged over all well sections drilled using NABF does not exceed 6.9 percent wet weight base fluid retained on cuttings.

Also, in alignment with the Payara Environmental Permit, EEPGL will continue to (1) visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings; (2) prohibit the discharge of cuttings generated using drilling fluids that contain conventional mineral oil, except when the mineral oil is used as a carrier fluid (transporter fluid), lubricity additive, or pill; (3) prohibit the discharge of drilling fluids that contain used/waste engine oil, cooling oil, gear oil or lubricant, and which have previously been used for purposes other than borehole lubrication; (4) prohibit use of fluids that contain diesel as the principal component of the drilling mud liquid phase; and (5) for well sections requiring NADF, use only low-toxicity IOGP Group III base fluid.

Environmental Aspects and Impacts

As described in the Liza Phase 1, Liza Phase 2, and Payara EIAs and this EIA, EEPGL will mitigate impacts from NADF cuttings discharges by well as follows:

- Use low-toxicity IOGP Group III NADF and manage in accordance with the associated safety data sheet.
- Use solids control and cuttings dryer systems to treat cuttings such that end-of-well maximum-weighted mass ratio averaged over all well sections drilled using non-aqueous fluids shall not exceed 6.9 percent wet weight base fluid retained on cuttings.

As reflected in the Liza Phase 1, Liza Phase 2, Payara EIAs, and this EIA—and as supported by cuttings discharge modeling—the significance of impacts on marine benthos as well as water and sediment quality is considered Negligible when using the 6.9 percent by wet weight concentration of NABF on cuttings through existing solids control and cutting dryer systems. Furthermore, actual drilling operations are consistently achieving an even lower average of less than 4 percent. This conclusion is also consistent with published investigations of the fate of cuttings in offshore discharges (IOGP 2016b).

The wellheads will be clustered around major drill centers rather than being distributed over the seabed above the producing reservoirs. This approach reduces the number of drilling locations, thereby reducing the seabed area potentially affected by drilling operations, including discharge of drill cuttings. The planned development drilling program and its cuttings management approach are consistent with good international oilfield practice (World Bank 2015) and have

previously been the basis for exploration wells in the Stabroek Block; they are also the basis for the development wells for the Liza Phase 1, Liza Phase 2, Payara, and Yellowtail Development Projects.

The embedded controls in the Project design that will reduce the potential impact of drilling discharges on sediment quality include: (1) use of WBDF to the extent reasonably practicable (for drilling of initial open-hole well sections), and (2) use of IOGP Group III NADF in all other cases. WBDF contains no hydrocarbons; accordingly, no treatment of WBDF-based cuttings is required. When NADF is used, the discharge of treated cuttings will be controlled such that residual base fluid content on discharged cuttings will average no more than 6.9 percent (wet weight). The NABF to be used in the NADF will be IOGP Group III, with low to negligible aromatic content, reducing the potential that changes in sediment quality as a result of discharge of the treated cuttings will lead to potential toxicological impacts on benthic fauna.

Discussion and Conclusion

The drill ships supporting the Project will use a performance criterion for overboard discharge of NADF which does not exceed 6.9 percent wet weight base fluid retained on cuttings average by well. This performance criterion is consistent with the World Bank guidelines for existing facilities (World Bank 2015), as well as performance criteria and good international oilfield practice.

2.18.3.2. Gas Processing

Technology Options and Selection, Technical Feasibility, and Economic Feasibility

To re-inject gas into a reservoir, the gas temperature, pressure, and composition have to meet the reservoir re-injection requirements. The gas treatment process includes heat exchangers and compressors to achieve desired re-injection conditions. For the Guyana projects, several stages of compression are included in the design. Moreover, natural gas usually contains significant amounts of water vapor. This water must be removed to mitigate the risk of flow capacity issues, hydrate formation, and corrosion issues in downstream systems. Thus, the gas treatment process also includes a dehydration unit. The gas dehydration technology selection has an impact on energy consumption, and therefore GHG emissions.

Three gas-dehydration processes were considered: absorption dehydration (e.g., TEG absorption), adsorption dehydration (solid desiccant adsorption, e.g., molecular sieve), and condensation.

Absorption Dehydration: The process scheme for absorption dehydration is illustrated on Figure 2.18-13. In this method, process water is absorbed by TEG. Absorption is done in a glycol contactor (tray column or packed bed) by countercurrent flow of wet gas (at 35 to 40°C) and TEG. TEG is enriched by water and flows out in the bottom of the contactor, then runs through the flash drum and heat exchanger into the reboiler. In the reboiler, the water is boiled out. Regenerated (lean) TEG is then recycled through a heat exchanger back into the top of the TEG contactor.

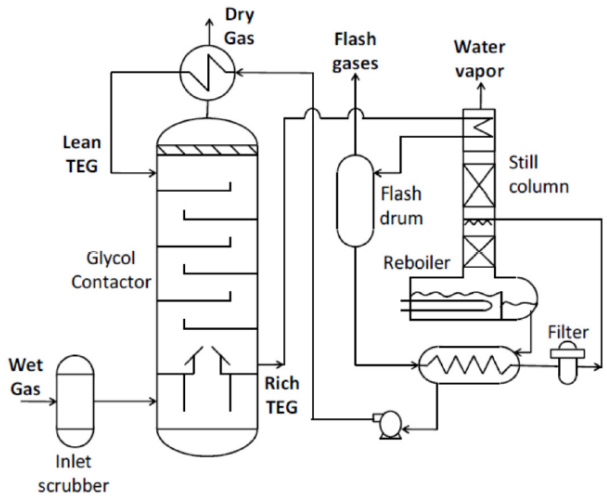


Figure 2.18-13: Process Scheme of TEG Absorption Dehydration

Adsorption Dehydration: In this method, solid desiccants (e.g., mole sieve, silica gel, or alumina) are used to adsorb water. As a minimum, two beds are used. Typically, one bed is drying gas and the other is being regenerated. Regeneration is done by preheated gas, as is shown on Figure 2.18-14 (Netusil and Ditl 2010). Typically, adsorption dehydration is applied in situations where extremely low dehydration specifications are required, such as natural gas liquids (NGL) recovery or liquefied natural gas production. Project requirements do not require this level of gas dehydration.

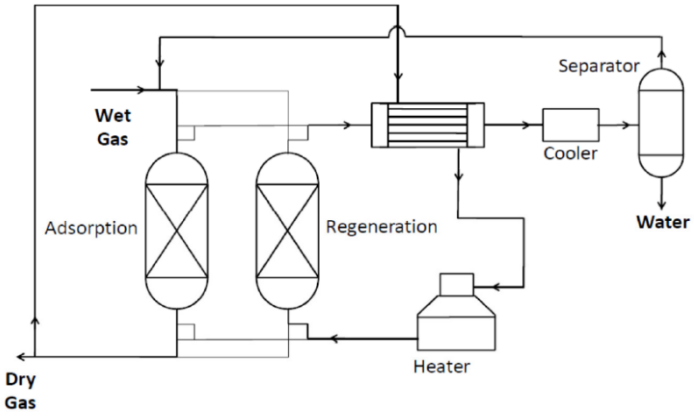


Figure 2.18-14: Process Scheme of Adsorption Dehydration Process

Condensation Dehydration: This method (Figure 2.18-15) employs gas cooling to condense water molecules into the liquid phase and then separating the water condensate from the gas stream (Guo and Ghalambor 2005). NGLs and condensed heavy hydrocarbons can also be recovered from the gas stream by cooling. Therefore, the condensation method is usually applied for simultaneous dehydration and recovery of NGLs.

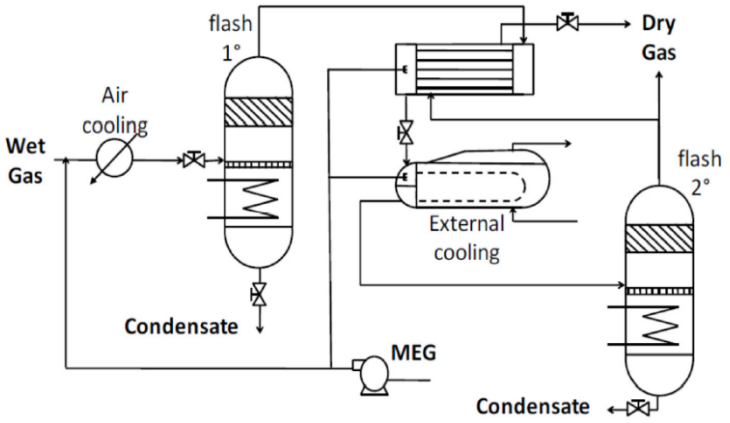


Figure 2.18-15: Process Scheme of Condensation Dehydration

To choose a suitable gas dehydration technology for the Project FPSO, several factors were evaluated including the water content specification of the gas after dehydration, size and weight of the dehydration equipment, and other factors. The size and weight of the dehydration process corresponds with the capital expenditure (CAPEX) required to install the equipment. Gas dehydration system energy consumption corresponds with operational cost.

The absorption dehydration system (i.e., TEG) has the lowest weight and space requirements and is therefore the lowest CAPEX technology that meets the Project gas dehydration specification.

Figure 2.18-16 compares the energy consumption of these three gas dehydration technologies. The energy calculations were performed on a model where 10^5 Nm^3/hour[29] water-saturated natural gas is processed at 30°C. In this comparison, the required outlet concentration of water in natural gas was set at a dew point temperature of -10°C at a gas pressure of 4 megapascal (MPa). The blue dashed line on the graph indicates the approximate operating pressure (9.6 MPa) of the dehydration process for Guyana projects.

[29] normal cubic meters per hour

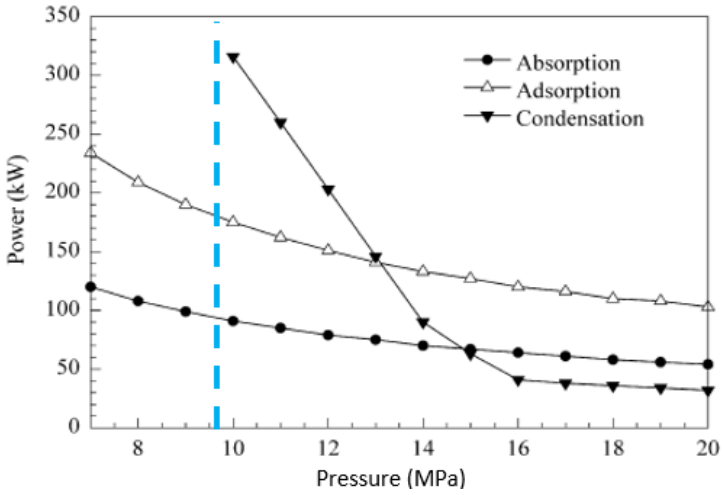


Figure 2.18-16: Modeling Results of Energy Consumption for Each Dehydration Method

Based on the total energy consumption, the most efficient dehydration operation is the absorption dehydration method (TEG) for the Project process conditions and gas dehydration specification. Thus, the Project selected the absorption dehydration method (TEG), as this technology has the lowest CAPEX and the lowest energy use of the considered options. The use of TEG gas dehydration in this application is consistent with GIOFP.

Regulatory Requirements/Benchmarking

The World Bank has established EHS guidelines for offshore oil and gas development (World Bank 2015) and general EHS guidelines (World Bank 2007), which are technical reference documents with examples of good environmental practices. The offshore oil and gas guideline states that new facilities should be designed, constructed, and operated so as to avoid routine flaring of associated gas. The guideline also states that methods for controlling and reducing fugitive emissions should be considered and implemented in the design, operation, and maintenance of offshore facilities and leak detection and repair (LDAR) programs should be implemented. The general EHS guidelines (World Bank 2007) state that the generation and release of emissions of any type should be managed through a combination of:

- Energy use efficiency;
- Process modification;
- Selection of fuels or other materials; and
- Application of emissions control techniques.

While the World Bank is not involved in the Project, the EEPGL gas processing system has been designed consistent with the good practices identified in the offshore oil and gas and general EHS World Bank guidelines.

Conditions of the Payara Environmental Permit state:

- Ensure all reasonable attempts are made to implement appropriate methods for controlling and reducing fugitive emissions in the design, operation, and maintenance of offshore facilities and to maximize energy efficiency and design facilities for lowest energy use, with

the overall objective to reduce air emissions. Environmentally effective and technically feasible best practices for reducing emissions must be evaluated and adopted as far as practicable.

Based on the above guidelines and requirements, the FPSO gas processing system was designed to align with prior Environmental Permit conditions, maximize energy efficiency, and minimize environmental impacts.

Environmental Aspects and Impacts

As outlined in the World Bank general EHS guidelines (World Bank 2007), energy efficiency options should be evaluated. Various gas-processing systems were evaluated, and it was determined that the use of the absorption dehydration method (TEG) as the gas processing dehydration technology is the least energy intensive option, which also means it has the lowest GHG emissions of the technology options considered.

Discussion and Conclusion

The gas-processing system for the Project has been designed and will be operated consistent with the World Bank EHS guidelines (World Bank 2007) described above and to ExxonMobil internal environmental standards. EEPGL has designed and will operate the Project FPSO consistent with these guidelines as well as the Guyana EPA Environmental Protection Act and prior Environmental Permit conditions. EEPGL's decision was based on a defined decision-making process, including the evaluation of technical feasibility, economics, regulatory requirements, environmental impacts, and good international oilfield practice.

2.18.3.3. Injection Compressors

Technology Options and Feasibility and Economic Evaluation

Injection compressors will operate at high pressures (pressures greater than 500 bars), similar to past development projects and well within the capabilities of available technology. Three suppliers are qualified based on their experience in safely and reliably building compressors for the required pressures and flow rates for the Project. In addition to evaluating manufacturer's experience, the compressor design on previous Guyana FPSOs have been audited by subject matter experts to assess safe and reliable design. Furthermore, for Yellowtail, a full-pressure, full-load hydrocarbon test[30] will be conducted on the compressor at the manufacturer's shop to prove that the performance of the compressor meets the design requirements.

The compressors use dry gas seals to seal the compressor and minimize risk of leakages. The dry gas seals are equipped with instrumentation that alerts the operator and shuts down the compressor in case of damage to the seal. The seals are supplied with a primary and backup source of clean dry gas.

For Yellowtail, the re-injection compressors will be arranged in a 3 x 50% configuration (three compressors at 50 percent capacity each). During instances where one compression unit is

[30] American Society of Mechanical Engineers—Performance test code 10 (ASME PTC-10) type I

offline for upset or maintenance, installed spare compression equipment can be utilized to allow partial or full production to continue while reducing volume and duration of flared gas. The gas compression sparing capacity provided for Yellowtail exceeds that included in prior Guyana FPSOs.

Regulatory Requirements

The Guyana Environmental Protection Act has not established flaring standards. As such, EEPGL considered World Bank standards and internal ExxonMobil environmental standards as references. The World Bank has established EHS guidelines for offshore oil and gas development (World Bank 2015), which is a technical reference document with examples of good environmental practices. The offshore oil and gas development guideline states that new facilities should be designed, constructed, and operated so as to avoid routine flaring of associated gas. The guideline also states that methods for controlling and reducing fugitive emissions should be considered and implemented in the design, operation, and maintenance of offshore facilities and LDAR programs should be implemented.

ExxonMobil's internal environmental standards establish a design approach to reduce flaring emissions, which provides guidance that facilities should be designed to avoid routine flaring of associated gas and include an evaluation for the most advantageous use of alternatives for managing associated gas that would otherwise be flared.

The Payara Environmental Permit issued by the EPA in 2020, has the following relevant conditions:

- Ensure all reasonable attempts are made to implement appropriate methods for controlling and reducing fugitive emissions in the design, operation, and maintenance of offshore facilities and to maximize energy efficiency and design facilities for lowest energy use, with the overall objective to reduce air emissions. Environmentally effective and technically feasible best practices for reducing emissions must be evaluated and adopted as far as practicable.
- Operate all mechanical equipment in accordance with the manufacturer's guidance and/or Company and Operator best practices, as applicable.
- Routine flaring and venting is strictly prohibited (excludes tank flashing emissions, standing/working/breathing losses, low pressure streams) during any developmental drilling or production activities without EPA approval. Flaring is only permissible under the following conditions: Commissioning, Start-up, or Special Circumstances [these are further defined in the Permit].
- Ensure associated gas brought to the surface with crude oil during oil production is re-injected into the reservoir, and used as fuel gas on the FPSO. However, all feasible alternatives for gas use must be evaluated and adequately documented to the EPA upon request.

- Adopt risk management processes (e.g., hazard and operability study, hazard identification study, etc.) to assess risks associated with process upset and loss-of-containment events which could impact the environment.
- Employ all reasonable efforts to prevent equipment breakdowns and plant upsets that could result in flaring, and provisions must be made for equipment sparing and plant turn-down protocols. All equipment relating to the gas handling, water handling, and oil handling systems on the FPSO must be supplemented in accordance with the reliability study outcomes under Condition 3.16, which includes evaluation of equipment sparing, to be stored at a shorebase facility in Guyana or on the FPSO. Equipment spares must be located in Guyana before the Start-up and shall be maintained in accordance with Condition 1.11.

EEPGL elected to follow the World Bank offshore oil and gas development guidelines (World Bank 2015), its internal environmental standards, and the conditions in the Payara Environmental Permit for the design of the injection compressor system so that the BAT was selected for the Project.

Environmental Aspects and Impacts

Fugitive emissions from compressors are a source of potential air quality impacts. Consistent with best practices outlined in the World Bank EHS guidelines (World Bank 2007) and good international oilfield practice for management of fugitive emissions, EEPGL will control fugitive emissions from the injection compressors by implementing an LDAR program that regularly monitors to detect leaks, and repairs any leaks identified within a defined time period. Implementing an LDAR program will minimize impacts associated with GHG and other emissions to air.

Discussion and Conclusion

The use of injection compressors to inject associated gas into the reservoir for reservoir management is consistent with good international oilfield practice and the World Bank EHS offshore oil and gas development guidelines (World Bank 2015). EEPGL has designed and will operate the Project FPSO consistent with these guidelines as well as those of the Guyana Environmental Protection Act, and in alignment with the Payara Environmental Permit conditions. EEPGL's selection of the injection compressors was based on a defined decision-making process including the evaluation of technical feasibility, economics, regulatory requirements, environmental impacts, and good international oilfield practice.

2.18.3.4. Power Generation

Technology Options and Feasibility and Economic Evaluation

The power-generation system for the Project was selected after taking into account technical feasibility and economic evaluations with a consideration of regulatory requirements and potential environmental impacts. The power-generation system has been designed consistent with GIOFP and will be operated consistent with internationally recognized environmental performance criteria for the offshore oil and gas industry.

The electric power demand for the FPSO was estimated, and based on that power demand, potential options for power generation were evaluated. Power demand for the FPSO was estimated based on anticipated flow rates from multiple reservoir scenarios. Several cases were evaluated for optimum configuration of electric consumers of the major loads.

Options considered for power generation included reciprocating engine-driven generators and turbine-driven generators. Nuclear, wind, and wave energy were ruled out as technically infeasible power sources due to distance from shore, requirement for a steady power supply, and lack of existing infrastructure. Steam turbines in single cycle as an overall power-generation method were ruled out given low thermal efficiency and in combined cycle given increased weight, space, and water-treating requirements. Gas turbines are the industry-preferred method of generating electricity in the required power range for offshore applications. This is because turbines require a smaller footprint and require less maintenance compared to reciprocating engines. For example, several additional reciprocating engines would be required compared to the number of required turbines; this incremental equipment would negatively impact the FPSO equipment layout. While a detailed economic analysis of power generation options is beyond the scope of the EIA, these economic drivers support the selection of turbine-driven generators as the preferred technology for power generation.

Once turbines were selected as the preferred power-generation source, individual turbine capacity was evaluated to minimize footprint while providing a reliable power source that achieved the required power demand. To provide continuous power in an isolated offshore location, good international oilfield practice is to install power generation in an “N+1” configuration. This means that there is an installed spare generator, such that during planned and unplanned generator outages, production is not impacted. Additionally, to promote reliability of the power generation and distribution system, the system is split into three electric buses with generators distributed to provide load-shedding capabilities in case of upsets in parts of the system. Therefore, to promote reliability and optimize the load balance between gas turbines, a “4+1” configuration was selected.

Turbines were evaluated further to facilitate selection of the BAT. There were several options evaluated, which included industrial turbines and aero-derivative turbines. Aero-derivative turbines were selected over industrial turbines due to the higher efficiency resulting in an approximate 5 to 6 percent reduction in fuel consumption. This resulted in approximately 1.5 MMscfd reduction in fuel consumption at peak load, thereby reducing GHG emissions.

Available fuel sources (diesel and natural gas) for the turbines were also evaluated taking into consideration operating expense and emissions. Natural gas will be readily available offshore and is the cleanest-burning and lowest-cost source of fuel and was therefore selected as the primary source of fuel for the gas turbines.

Additionally, the turbines are designed with dual-fuel capabilities to run on diesel when natural gas is not available during FPSO shutdowns or process upsets. The turbines are designed to switch automatically to diesel in case of upset in the fuel gas system. This increases the uptime of the facility, which reduces the overall emissions by reducing flaring caused by start-up and shutdown of the facility.

To further increase energy efficiency of the FPSO, the option of using waste heat recovery was selected. Waste heat recovery is a process by which residual heat (called waste heat) from the gas turbine exhaust is recovered in a waste heat recovery unit (WHRU). This captured waste heat is then transferred to a heating medium system that provides heat for various users on the FPSO. For example, the oil treating process requires heating of the oil to meet the oil product specification. This heat input could be provided by a fired-gas heater or by using the waste heat from the gas turbines via the heating medium system. If fired-gas heaters were used in this service, natural gas usage (fuel for the heater) would increase by approximately 5 to 6 MMscfd. Alternatively, the heating demand could be met by WHRUs with minimal additional investment and relatively low incremental power consumption. This reduces FPSO fuel consumption by approximately 15 percent.

Nitrogen oxide (NO_x) control technologies were evaluated for the Project. Based on World Health Organization (WHO) guidelines and internal ExxonMobil standards, it was determined through modeling that advanced NO_x control is not required for the gas turbines, as the PDA is approximately 203 kilometers (126 miles) from shore. The maximum predicted onshore NO_x emissions from the Project are no more than 6.2 percent of the ambient air quality guidelines based on the distance to shore. Implementing advanced NO_x control would result in increased cost and lower reliability of the system. This lower reliability would result in higher GHG emissions caused by process upsets. Therefore, with an understanding that advanced NO_x control would provide limited reduction in an already negligible impact to onshore receptors, it was decided not to implement additional NO_x controls on the FPSO.

Regulatory Requirements/Benchmarking

The Guyana Environmental Protection (Air Quality) Regulations 2000 gives the EPA authority to establish national ambient air quality standards and parameter limits, although none have been established to date. As such, EEPGL considered WHO air quality guidelines as recognized international standards for the design and operation of the power generation system (WHO 2005).

The Payara Environmental Permit issued by the Guyana EPA in 2020 mandates the following:

- Ensure all reasonable attempts are made to implement appropriate methods for controlling and reducing fugitive emissions in the design, operation, and maintenance of offshore facilities and to maximize energy efficiency and design facilities for lowest energy use, with the overall objective to reduce air emissions. Environmentally effective and technically feasible best practices for reducing emissions must be evaluated and adopted as far as practicable.

Based on the above guidelines and prior Environmental Permit conditions, the FPSO power generation system was designed to maximize energy efficiency and minimize environmental impacts.

Environmental Aspects and Impacts

Power generation is the main source of air emissions from the FPSO. Through the evaluation of technical and economic feasibility, as well as applying relevant recognized international environmental guidelines, EEPGL has also minimized environmental impacts.

An analysis of energy efficiency improvements, considering cost-reduction opportunities, was conducted and the technically feasible and cost-effective opportunities were pursued. These minimized the amount of GHG and other emissions to air being generated from the power system. The decision to pursue aero-derivative turbines versus industrial turbines was driven by increased energy efficiency. Additionally, WHRUs were pursued over fired heaters due to increased energy efficiency. These improved energy-efficiency options result in lower generation of GHG emissions.

Good international oilfield practice also dictates that emissions should be managed through the selection of fuels (World Bank 2015). As described above, the use of natural gas over diesel as the primary fuel source for the power generation system is more environmentally beneficial since the combustion of natural gas, which is a less carbon intensive fuel option as compared to diesel, generates less air emissions.

Good international oilfield practice also dictates that emissions should be managed through process modifications (World Bank 2015). The FPSO power generation system was designed to improve reliability of the system by including a spare generator to reduce upset time, which results in less flaring emissions. Additionally, designing the turbines as dual fuel improves reliability, and therefore decreases flaring emissions due to upsets, by allowing the turbines to run on diesel when fuel gas is not available.

Lastly, due to the distance of the FPSO from shore, advanced NO_x controls were determined not to be warranted due to the negligible predicted impacts to onshore receptors. A baseline air quality assessment was conducted and atmospheric dispersion modeling was performed to assess potential ground level concentrations. Modeled concentrations of air pollutants at potential onshore receptor locations were compared to guideline concentrations from WHO, which demonstrated that the maximum predicted onshore concentrations are significantly below the WHO guidelines (WHO 2005).

Further, the ESMP describes EEPGL's monitoring program for sources of air emissions:

- Equipment will be maintained in good working order and operated in accordance with manufacturer's guidance and/or Company and Operator best practices, as applicable;
- Inspection, maintenance, and surveillance programs will be implemented to identify and prevent leaks; and
- Fuel consumption will be metered or estimated.

Discussion and Conclusion

In summary, the gas turbines selected for the Project provide a reliable source of power for the FPSO that is cost effective and technically feasible. Additionally, the aero-derivative gas

turbines are energy efficient, which is further enhanced by use of WHRUs. Furthermore, the units are designed with dual fuel capabilities with improve reliability/uptime with natural gas being the primary source of fuel. Natural gas is a clean burning fuel source with the additional benefit of being the lowest cost option.

EEPGL has designed and will operate the FPSO consistent with the WHO air quality guidelines performance criteria (WHO 2005), as well as the Guyana EPA Environmental Protection Act and the Payara Environmental Permit conditions for the FPSO power generation system.

2.18.3.5. Produced Water Treatment

Technology Options and Feasibility and Economic Evaluation

Selecting produced water treatment systems depends on the produced water characteristics (e.g., temperature, oil content, solids content, droplet, solid particle size, and pressure) and the target quality of effluent. The design of produced water treatment systems considers the type of field (onshore or offshore) and the available discharge alternatives. Generally, for offshore facilities, a multi-stage water treatment process is implemented so that water quality standards can be achieved.

Gravity, enhanced gravity separation, and flotation units are commonly used as primary and secondary water treatment processes, while filtration and membranes are commonly used in the tertiary treatment / water polishing stage, if needed. Tertiary treatment is not required for produced water overboard discharge. Typical de-oiling equipment performances for primary and secondary water treatment technologies are compared in Table 2.18-5.

Table 2.18-5: Typical De-Oiling Equipment Performance

Equipment Type	Typical Maximum Inlet Oil Concentration (mg/L)	Typical Minimum Outlet Oil Concentration (mg/L)	Advantages	Disadvantages
Plate Separators	5,000	100	No moving parts, can be used in two-stage treating	Periodic cleaning required, size and weight
Skim Tanks	10,000	150	Oil removal and droplet growth before final treatment	Secondary treatment required, size and weight
Coalescers	2,000	100	No moving parts, can be used in two-stage treating	Cleaning required, size and weight
Hydrocyclones	2,000	20	Final treatment, small size and weight, no moving parts	Turndown, plugging due to solids
Induced Gas Flotation	2,000	20	Final treatment, high water quality	Cleaning required, size and weight
Centrifuges	200	20	Final treatment, high quality water, turndown	Cost, rotating equipment maintenance, large power demand

Hydrocyclones are devices that separate oil from produced water by means of centrifugal force and are the most cost-effective solution for produced water treatment due to low operating cost and high reliability. Moreover, hydrocyclones can separate oil droplets down to 15-µm size and consistently remove 90 percent or more of the oil present in the inlet flow stream. Unlike other technologies (e.g., skim vessels and plate separators), hydrocyclones are compact modules and highly efficient. Furthermore, they can handle a wide range of oil concentrations and are insensitive to platform motions.

Induced Gas Flotation Units are a leading technology for secondary treatment of produced water. They use dispersed bubbles to contact oil droplets in the water, which float to the surface as froth. The Induced Gas Flotation Units are typically designed to remove emulsified oil droplets of 20 µm diameter and greater. Minimal power requirement and minimal controls result in low operating cost as well as easy and robust operation.

Centrifuges are a mechanical process that uses an applied centrifugal force to separate oil from water based on density and particle size difference. However, centrifuges are a highly energy-intensive process, resulting in high operating cost and maintenance. For the treatment of produced water at a large scale, water treatment with centrifuges requires a significantly large capital investment.

Other technologies, such as plate separators, coalescers, and skim tanks, can be chosen for primary or secondary treatment; however, mechanical cleaning is often required for these technologies. In addition, these technologies have a large footprint and weight, which are disadvantages for offshore deployment.

The combination of a hydrocyclone and an Induced Gas Flotation system provides a cost-effective and reliable process to treat produced water in order to meet regulatory requirements for water discharge to the environment. For Yellowtail (as well as previous Guyana development projects), a combination of a hydrocyclone and an Induced Gas Flotation system has been selected for primary and secondary treatment, respectively, for meeting the overboard discharge quality standards of the projects.

Regulatory Requirements/Benchmarking

The Guyana Environmental Protection Act has no offshore discharge standard for produced water. As such, EEPGL considered three international standards for the design and operation of the produced water treatment system: the World Bank, the USEPA, and the OSPAR Convention. While these standards are not requirements for the Project, they are relevant as international guidelines that represent good international oilfield practice.

The World Bank Group has established EHS guidelines for offshore oil and gas development (World Bank 2015), which is a technical reference document with examples of good environmental practices. The offshore guideline has established an effluent guideline of oil and grease content in produced water of no more than 42 mg/L daily maximum, and no more than 29 mg/L monthly average. The EEPGL produced water system design basis is consistent with the performance criteria of the above-referenced guidelines for oil and grease content.

The USEPA's Oil and Gas Extraction Effluent Guidelines and Standards (40 CFR Part 435) have established effluent limitations guidelines representing the degree of effluent reduction attainable by the application of BAT, whereby point sources must achieve effluent oil-in-water limitations of a maximum for any one day not to exceed 42 mg/L and the average of daily values for 30 consecutive days not to exceed 29 mg/L.

Similar to the above standards, the OSPAR Convention sets a performance standard of 30 mg/L for dispersed oil in produced water as the maximum monthly average concentration to be discharged. This performance criterion is consistent with both the World Bank and USEPA standards.

The EEPGL Liza Phase 1, Liza Phase 2, and Payara Environmental Permits issued by the EPA in 2017, 2019, and 2020, respectively, have the following condition:

> "Produced water from the reservoir will be treated onboard the FPSO to an acceptable specification prior to discharging. The oil content specification of produced water to be discharged shall not exceed 42 mg/L on a daily basis or 29 mg/L on a monthly average. If the oil content of produced water is observed to exceed these limits, the produced water shall be routed to an appropriate storage tank on the FPSO until the treatment system is restored, and the discharge meets the specification above."

EEPGL elected to use an FPSO produced water treatment system design and discharge basis for the Project that is consistent with international produced water discharge performance criteria.

Environmental Aspects and Impacts

Following the above performance criteria for produced water discharge, predicted impacts to water quality were concluded to have a Negligible significance in the Liza Phase 1, Liza Phase 2, Payara, and Yellowtail EIAs. Further, the Liza Phase 1, Liza Phase 2, Payara, and Yellowtail ESMPs describe EEPGL's monitoring program for produced water discharges:

- A minimum of one grab sample will be taken each day to monitor compliance with the daily maximum oil-in-water content of 42 mg/L. Samples will be analyzed for oil and grease content using an industry standard method in the lab on board the FPSO. Results will be documented in a log. A monthly average will be recorded to monitor compliance with the monthly average oil-in-water content of 29 mg/L.
- Each Induced Gas Flotation Unit will have a dedicated online oil content analyzer that provides continuous oil content monitoring for the treated produced water stream. The control system will automatically route water to the off-spec tank if an oil content of 42 mg/L is exceeded. The online analyzer is an inline device that uses fluorescence to provide continuous accurate measurements of oil concentrations in water. Once the automated system routes the produced water stream to the off-spec tank, it remains in that mode until such time as the operator returns the system back to overboard discharge mode. This will occur once the operator confirms that issues with the produced water treatment system

have been rectified and the produced water stream is meeting overboard discharge specifications. From the off-spec tank, the produced water will be returned to the topsides Induced Gas Flotation Unit for further treatment. In the event of unavailability of the off-spec tank, the produced water will be transferred to slop tanks. If the produced water is routed to the slop tanks, any overboard water discharge from the slop tanks will not exceed 15 ppm oil content.

The performance of the produced water treatment system is guaranteed by the selected equipment supplier for all normal operating conditions. The design and discharge basis of the Project FPSO produced water treatment systems, supported by the required environmental monitoring program, are aligned with the World Bank, USEPA, and OSPAR produced water discharge performance criteria and will have a Negligible impact on water quality.

Discussion and Conclusion

Overboard discharge performance criteria of produced water is consistent with the World Bank offshore oil and gas development EHS guidelines (World Bank 2015), the USEPA's Oil and Gas Extraction Effluent Guidelines and Standards (40 CFR Part 435), and the OSPAR Convention. EEPGL has designed and will operate the Project FPSO consistent with these guidelines, as well as the Guyana Environmental Protection Act and prior Environmental Permit requirements. EEPGL's decision to not inject treated produced water was based on a defined decision-making process including the evaluation of technical feasibility, economics, regulatory requirements, environmental impacts, and good international oilfield practice (World Bank 2015).

2.18.3.6. Seawater Treatment

Injection of seawater into the reservoir for pressure maintenance is a good international oilfield practice in offshore facilities (World Bank 2015). However, the presence of sulfate ions (approximately 2,800 to 3,000 mg/L) in the seawater, in combination with high concentrations of barium or strontium often found in reservoir formation waters, is a source of potential scale formation in the reservoir that could reduce seawater injectivity over the life of the field. To prevent this scale formation at the seawater injection wells, good international oilfield practice is to reduce the amount of sulfate ions in the seawater before it is injected into the reservoir.

A further benefit of reducing the sulfate concentration in the injected seawater is the minimization of reservoir souring. Reducing the sulfate concentration in the injected seawater minimizes the H_2S generated in the reservoir by sulfate-reducing bacteria. Minimizing reservoir souring reduces equipment corrosion issues during the facility life and reduces likelihood that future equipment is required for scrubbing, removal, and handling of H_2S. Seawater also contains particulates that can reduce seawater injectivity directly into the reservoir, and removal of particles is also part of good international oilfield practice for offshore facilities.

Other than reservoir injection, seawater is also used to generate wash water for crude oil de-salting. In order to use seawater to generate wash water for this purpose, salt ions contained in the seawater first need to be reduced via a desalination process.

Technology Options and Feasibility and Economic Evaluation

The most common way to desalinate seawater is either via membrane techniques such as reverse osmosis or thermal techniques such as distillation. Membrane techniques require less energy than thermal techniques due to the lack of heating requirement. Membrane techniques also take up a smaller footprint. Seawater reverse osmosis is an environmentally friendly and standard technology in the offshore oil and gas industry and therefore has been selected for Yellowtail.

Removal of Sulfates

The required seawater injection product specification is less than 40 ppm sulfates. Two sulfate removal technologies were considered in this application. The first technology considered, precipitation of sulfates by chemical addition, cannot achieve the less-than-40 ppm sulfate target. The second technology considered, the nanofiltration membrane process, is a proven industrial technology for this application.

Nanofiltration is a membrane process that selectively removes sulfate ions to produce low-sulfate injection water. The process is similar to reverse osmosis, used extensively worldwide for seawater desalination. The nanofiltration membrane has a larger pore size and possesses a slight negative charge and thus can reject divalent ions (e.g., sulfate). The nanofiltration membrane has feed-to-permeate conversion at 75 percent of the inlet flow rate. For every 100 bbl (16 m^3) of seawater that flows to the system inlet, 75 bbl (12 m^3) of low-sulfate water are produced, and 25 bbl (4 m^3) of high-sulfate water are disposed of overboard. This high-sulfate water is typically referred to as a brine.

Sulfate content of less than 40 ppm in injected water can be further reduced to less than 10 ppm by deploying nanofiltration units in series. However, this incremental equipment increases system complexity and cost and reduces the reliability of the SRU. Implementing incremental sulfate reduction beyond the less-than-40 ppm target was not pursued.

Removal of Particulates

Seawater treatment requiring sulfate removal using a nanofiltration membrane requires particles larger than 2 microns to be removed prior to the sulfate removal step. Two particle removal technologies were considered in this application. The first technology considered was multi-media filters (MMF) with a guard filter. The second technology considered was ultrafiltration (UF). Both industrial technologies are proven for this application.

The first technology, MMF, is a filter bed that typically contains three layers of media consisting of anthracite, sand, and garnet, with a supporting layer of gravel at the bottom. Inside the MMF vessel, seawater flows down through the bed to produce cleaner filtrate at the bottom while retaining particulate in the media. Typically, MMF is able to remove particles down to 10 microns. Chemicals such as polyelectrolytes are normally required to be injected upstream of MMF to aid the filtration process. The seawater particulate retained with the bed must be removed by a backwash process, which is typically triggered by a high bed differential pressure. During backwash, it is typical that media is partially lost and filtration efficiency will thus

gradually reduce over time. Hence, media top-ups are needed and, in many cases, need to be completely replaced every couple of years.

Downstream of MMF, a guard cartridge filter is required to capture any potential media or sand carry over from MMF and also further remove particles down to 5 microns or lower before routing the pretreated water to an SRU using nanofiltration membranes. The guard cartridge filter is progressively fouled, requiring manual replacement by operators and disposal of used filter elements.

The second technology, UF, is a membrane filtration process capable of removing particles down to the range of 0.03 microns. It involves flow of feed seawater via a pressure gradient applied across hollow fiber polymeric membranes, which separates the impurities from the water. The flow pattern follows an outside-in pattern, wherein the feed will flow along the outside of the hollow fiber membrane. Filtrate will permeate through the membrane and collect on the inside, flowing to the downstream unit via a discharge header. The rejected particulates will be collected on the outside of the membrane and will be removed by periodical washing. Unlike MMF, no particulate generation via media loss is involved in normal operation for UF. This, and the high filtrate quality that UF generates, eliminate the need for a guard filter downstream of UF.

UF was selected over MMF+guard filter for the Project because it provides substantially improved pre-treated water quality for the downstream SRU (e.g., filtrate with solid particle <0.03 micron by UF vs <2 micron by MMF+guard filter). This results in significant saving in operating expense by extending the downstream SRU membrane clean-in-place frequency. UF also eliminates the need for a guard filter, and thus the manual replacement and waste disposal of the used filter elements throughout production life. A UF membrane typically lasts 6 to 10 years, contrasting to the requirement of MMF for media top-off or replacement every 3 years. All of these advantages rendered by UF compared to MMF+guard filter translate to higher availability and reliability of seawater treatment to achieve the high water injection volume that is needed to maintain reservoir pressure to sustain or accelerate oil production and recovery. Furthermore, UF provides considerable savings in weight and footprint as compared to MMF+guard filter. As much as one entire module size of footprint on the FPSO could be saved, allowing capital expense reduction and/or enabling higher production throughput within the footprint and weight constraints of the FPSO.

The reliability of the seawater treatment system is enhanced through the use of multiple units and membranes, including sufficient sparing, to be able to maintain treatment system functionality. The main flow path for seawater treatment is through coarse filtration, ultrafiltration, and a sulfate removal membrane unit before heading into a de-aeration column. To maintain capacity / availability, the coarse filtration, ultrafiltration, and SRUs all have spares to allow continued operation in the event a unit needs to be taken out of service temporarily. Additionally, throughout the seawater treatment system, seawater lift pumps, feed pumps, and water injection booster pumps also have spares for the same purpose.

Regulatory Requirements

In Guyana, no offshore ambient water quality standards exist for the constituents in the Sulfate Removal, Ultrafiltration, and Wash Water Processing Brines.

The Liza Phase 1, Liza Phase 2, and Payara Environmental Permits issued by the EPA in 2017, 2019, and 2020, respectively, have the following condition:

- Marine discharges from well drilling, hydrostatic testing of flow lines and risers, and the overall production operations shall be undertaken in a manner that does not cause or permit the entry of contaminants into the environment in amounts, concentrations, or levels in excess of that prescribed by the regulations or stipulated by any environmental authorization.

Environmental Aspects and Impacts

Using the recommended design basis for seawater treatment, impacts on water quality were concluded to be Negligible in the Liza Phase 1, Liza Phase 2, Payara, and Yellowtail EIAs. No treatment of the brine streams is required prior to discharging overboard since the streams are essentially seawater. Discharge of sulfate removal, ultrafiltration, and wash water processing brines can result in localized increases in concentrations of chemical constituents in the marine environment. Cooling water, produced water, and brines from the SRU, ultrafiltration, and wash water reverse osmosis system are the operational discharges that were the focus of modeling performed for the EIA to assess the nature and extent of potential marine water quality impacts.

The USEPA-approved CORMIX dilution model was used to predict the nature and extent of discharge plumes from the various modeled discharges. The model showed that at 100 meters (328 feet) from the discharge point, a greater than 98 percent reduction in sulfate removal, ultrafiltration, and wash water processing brines concentrations was achieved. The modeling of potential impacts from the discharges found that even under the most conservative bounding case for each discharge-modeling scenario, the discharges were subject to rapid mixing and consequently experienced substantial reductions in constituent concentrations within a relatively small distance from the point of discharge.

Since there are no prescribed limits for the constituents contained in the seawater treatment processing brine stream and water quality modeling demonstrated a Negligible impact on the marine environment, the system has been designed to minimize impacts on the environment and therefore, the best available techniques have been used.

Additionally, the least energy-intensive technology was selected for sulfate removal compared to the addition of incremental nanofiltration units in series, which means associated GHG emissions from energy use have been minimized as well, reducing air quality impacts.

Consistent with the Liza Phase 1, Liza Phase 2, Payara, and Yellowtail ESMPs, EEPGL will perform daily visual inspections on the FPSO of discharge points to confirm that there are no floating solids or discoloration of the surrounding waters and will document observations.

Discussion and Conclusion

EEPGL has designed and will operate the Project FPSO to treat seawater via nanofiltration, ultrafiltration, and reverse osmosis technologies. These technologies have minimal environmental impact and comply with the Guyana EPA Environmental Protection Act and the prior environmental permit conditions for the overboard discharge of the resulting brine streams. EEPGL's selection of the seawater treatment technologies was based on a defined decision-making process including the evaluation of technical feasibility, economics, regulatory requirements, environmental impacts, and good international oilfield practice.

2.18.4. No Action Alternative

The "no action" alternative means that the Project would not be executed. If this alternative is selected, the existing conditions described in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources, would remain unaffected by the Project and the potential positive and negative impacts assessed in these chapters would not be realized.

It is reasonable to expect that some environmental and socioeconomic conditions would likely change over time in the absence of the Project. In particular, without the Project's revenue sharing with the Government of Guyana, the associated potential for benefits to socioeconomic resources would be reduced and gross domestic product (GDP) growth through associated fiscal revenue would be affected. The National Resource Fund would be deprived of these revenues for sustainable development of the country and initiatives aimed at achieving the government's vision of an inclusive green economy would likely be reduced. The Government of Guyana would also not be able to take advantage of the Project revenues to fulfill its objectives to create more job opportunities, address poverty, and improve the overall quality of life (IDB 2017).

Opportunities to boost economic growth through increased foreign direct investment in supporting goods and services in the time leading up to oil production would be reduced. Whereby economic growth was projected to hover around 3.5 percent from 2017 to 2019, the Inter-American Development Bank predicted that once oil production starts, GDP growth will reach 38.5 percent in 2021 (based on consideration of a 100,000 barrels per day (16,000 m^3/d) production rate for 8 years [referring to production from Liza Phase 1 Development Project only]) (IDB 2017). Without the Project, these levels of GDP growth rate would be less achievable. Additional effects on the economy if the Project were not enacted would likely include a reduction in demand for goods and services from Guyanese businesses and employment opportunities for Guyanese nationals who would have benefited from the Project. The absence of the Project would also eliminate associated induced economic benefits resulting from the re-investment, hiring, and spending by Project-related businesses and/or workers, which in turn benefits other non-Project-related businesses and generates more local tax for the government.

While a No Action alternative would decrease opportunities for the country to grow its economy and diversify production and trade, there are potential economic benefits. These include, but are not limited to, decreased economic dependence on natural resources, decreased economic vulnerability to commodity price fluctuations, and reduction in the competitiveness of other sectors.

Therefore, evaluating the No Action alternative means evaluating the tradeoff between positive and negative impacts.

With respect to the possibility of EEPGL electing to not finish the Project after initiating its execution, a primary decision point is Final Investment Decision, when EEPGL and its co-venturers make a formal decision to proceed with full Project implementation. Once that point is reached, it is unlikely that the Project would not be progressed through full implementation. However, in the unforeseen event that circumstances arose that warranted stopping the Project mid-development, EEPGL would abandon the (partially implemented) Project infrastructure in an appropriate manner, consistent with the concepts laid out in the Preliminary End of Project Decommissioning Plan (included in Volume III of the regulatory submittal).

2.18.5. Summary of Alternatives

EEPGL considered a range of alternatives for the various aspects of the Project, along with the potential environmental and socioeconomic impacts associated with these alternatives. The preferred alternatives, which comprise the Description of the Project, reflect EEPGL's identification of the preferred alternatives from the standpoint of environmental performance, and technical and economic feasibility. This selection is supported by the fact that the FPSO and SURF production system is a proven development concept for deepwater oil recovery and would leverage both operator- and industry-proven technologies and experience.

2.19. QUALITY CONTROL

This section describes the ExxonMobil quality control process that will be implemented for the Project.

2.19.1. ExxonMobil Quality Control Process Overview

The objective of the ExxonMobil quality control process is to provide quality assurance oversight of the engineering, procurement, and construction contractors who will support the Project. The contractors themselves are responsible for the quality of the components and equipment. ExxonMobil processes are used to oversee contractor activities and monitor they are following the Project-approved procedures. Audits, assessments, and verifications are the main processes used for oversight.

2.19.2. Project Quality Management System

The Project Quality Management System consists of four main documents:

- Project Quality Plan
- Engineering Surveillance Plan
- Procurement Surveillance Plan (PSP)
- Construction Surveillance Plan (CSP)

Additionally, as a result of lessons learned from Liza Phase 1, currently there is an increased focus on quality assurance / quality control activities in the following areas:

- Inspections at suppliers during equipment fabrication;
- Surveillance during equipment preservation; and
- Internal assessments during FPSO fabrication.

Additional detail on the four above-referenced documents is provided below.

2.19.2.1. Project Quality Plan

Each project has a specific Project Quality Plan that outlines the requirements and expectations of the project team. This document outlines the plans and procedures to be used on the project. The detailed activities are listed in the plans themselves.

2.19.2.2. Engineering Surveillance Plan

The Engineering Surveillance Plan is the document used by the engineering team to conduct assessment and verification of the contractors' engineering activities. Periodic assessments are carried out by the package engineers. Verifications are conducted on documentation reviews of contractors' engineering processes, procedures, and specifications.

Assessments

- Appropriate design processes and associated quality assurance processes are assessed.
- Initial and periodic assessments are conducted.
- Engineering Specialists evaluate the suitability of contractors' design tools for the project.

Verifications

Engineering verification includes review of engineering products to confirm that engineering deliverables, including supplier designs, adhere to specifications, regulations, codes, and good international oilfield practice. In some cases, such as milestone design reviews and independent design verification, the contractor may have assigned responsibility and the project team can reference the contractor's program.

2.19.2.3. Procurement Surveillance Plan

The PSP outlines the oversight activities to be conducted by the quality team over all procured equipment. Workshops are held by contractors and ExxonMobil to determine the criticality of each component; this determines the amount of inspection oversight carried out by ExxonMobil.

Each individual engineering/procurement site (e.g., FPSO, Subsea, SURF) will prepare a site-specific or contract-specific PSP that incorporates program requirements. Assessment and verification activities will be used to monitor contractors and suppliers and associated work products. Results of assessments and verifications will be documented in a manner that identifies any deficiencies or quality issues, assigns action, and resolves the deficiencies/issues.

Assessments

To determine effective implementation of contractors' quality plans, the quality team conducts assessments as follows:

- Review Non-Conformance and Corrective Action Reports;
- Confirm contractor internal processes are followed;
- Confirm adequate quality and regulatory certification requirements;
- Confirm adherence to inspection/testing requirements; and
- Confirm adherence to access and notification requirements

Verifications

Verifications are a product-based activity that is carried out at supplier/fabrication facilities. This includes oversight of the supplier and the contractors' inspection teams. Deviations from specifications are documented and dispositions are tracked to completion.

2.19.2.4. Construction Surveillance Plan

A CSP is designed to assess contractor/subcontractor processes and activities and to verify their products. Each individual construction site will prepare a site-specific or contract-specific CSP that incorporates program requirements.

Assessments

- Initial assessment of contractor plans, procedures, and Inspection and Test Plans to determine if they convey suitable work processes, include all necessary components, and comply with contract requirements.
- Periodic assessments to determine if contractor is complying with the plans and procedures. These may be performed with the contractor or independently and may use various methods such as surveillance checklists or formal audits.

Verifications

- Verifications of work products to confirm that deliverables are in accordance with construction drawings, instructions, etc. The Project Team is also responsible for witnessing fabrication and testing to the degree necessary to assure that the final product is in compliance with project specifications.

2.19.3. Internal and External Auditing

The Project will implement an integrated audit program by combining resources with the contractors and participating in their respective audit programs. This approach will eliminate the redundancy of two separate audit programs. All audit schedules will be submitted to ExxonMobil for approval. Project audit participants will review and/or participate in the development of all audit checklists and questionnaires. This integrated approach does not eliminate ExxonMobil's ability to conduct audits independently.

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3. ADMINISTRATIVE FRAMEWORK

This chapter reviews the laws and regulations in Guyana that are relevant to the assessment of potential environmental and social impacts arising from the Project; the chapter is separated into five sections:

- Section 3.1, National Legal Framework, describes the laws and regulations that apply to environmental issues in a general context, such as the Constitution of Guyana, as well as national laws that focus specifically on environmental issues, such as the Environmental Protection Act as amended in 2005. This section also identifies several resource-specific environmental laws that are more narrowly focused and have either direct or indirect relevance to the Project.
- Section 3.2, Environmental Permits and Licenses, describes the major environmental-related permits and licenses EEPGL will be required to obtain to execute the Project.
- Section 3.3, National Policy Framework, describes the Government of Guyana's strategies and policies that apply to the Project. These strategies and policies articulate the government's management goals with respect to various environmental and social issues that could arise based on the Project's design and implementation.
- Section 3.4, International Conventions and Protocols, describes the international and regional conventions and protocols to which Guyana is a signatory and which are relevant to the Project.
- Section 3.5, EEPGL's Operations Integrity Management System, describes EEPGL's framework for addressing risks inherent in its business that can potentially have an impact on personnel and process safety, security, health, and environmental performance.

Table 3-1 lists applicable laws and regulations and the resources/receptors to which they apply. Additionally, Section 2.5 of the Environmental and Socioeconomic Management Plan for the Project (Volume III of the regulatory submittal) includes a number of environmental and socioeconomic performance criteria that, although not required pursuant to the applicable laws, regulations, and conventions discussed in this chapter, EEPGL will apply to the Project, consistent with good international oilfield practice.

3.1. NATIONAL LEGAL FRAMEWORK

This section provides an overview of the key legislation currently in force in Guyana that pertains to resources that could be affected by the Project.

3.1.1. National Constitution of Guyana

Guyana is governed according to the Constitution of the Co-operative Republic of Guyana, as amended (the Constitution). The Constitution took effect in 1980 and expressly provides for protection of the environment. Article 25 establishes "improvement of the environment" as a general duty of the citizenry. In addition, Article 36 reads as follows:

> "In the interests of the present and future generations, the State will protect and make rational use of its land, mineral and water resources, as well as its fauna and flora, and will take all appropriate measures to conserve and improve the environment."

3.1.2. The Environmental Protection Act

In 1996, the Environmental Protection Act (hereinafter referred to as the Act) was enacted to implement the environmental provisions of the Constitution. The Act is Guyana's single most significant piece of environmental legislation because it articulates national policy on important environmental topics such as pollution control and the requirements for environmental review of projects that could potentially affect the environment. It also provides for the establishment of an environmental trust fund. Most importantly, the Act authorized the formation of the EPA, and established the EPA as the lead agency on environmental matters in Guyana, including the issuance of environmental authorizations with appropriate conditions. The Act further mandates the EPA to oversee the effective management, conservation, protection, and improvement of the environment (EPA 2018). It also requires the EPA to take the necessary measures to ensure the prevention and control of pollution, assessment of the impact of economic development on the environment, and sustainable use of natural resources.

3.1.3. The Guyana Geology and Mines Commission Act

The Guyana Geology and Mines Commission Act was enacted in 1979 and authorized the government to establish the Guyana Geology and Mines Commission (GGMC), which is one of four agencies within the Ministry of Natural Resources. The GGMC promotes and regulates the exploration and development of the country's mineral and petroleum resources. The GGMC has a dedicated Petroleum Unit charged specifically with regulatory supervision of the oil and gas sector; however, regulation of petroleum-related activities also occurs in other divisions, such as the Geological Services Division and the Environment Division. Prior to 2020, the GGMC worked closely with the Department of Energy on matters related to the oil and gas industry. After 2020, the Department of Energy was absorbed into the Ministry of Natural Resources where the Petroleum Management Program regulates, manages, and monitors the exploration, development, and use of Guyana's petroleum resources.

3.1.4. Protected Areas Act

The Protected Areas Act was enacted in 2011. It provides for protection and conservation of Guyana's natural heritage and natural capital through a national network of protected areas. This act also allowed for the creation of the Protected Areas Commission to oversee the management of this network. It highlights the importance of maintaining ecosystem services of national and global importance and public participation in the conservation of protected areas. It establishes a protected areas trust fund to ensure adequate financial support for maintenance of the network. Other functions of this act include promoting national pride in and encouraging stewardship of Guyana's natural heritage; recognizing the conservation efforts and achievements of Amerindian villages and Amerindian communities; and promoting the recovery and rehabilitation of vulnerable, threatened, and endangered species.

3.1.5. The Petroleum Act

The Petroleum (Exploration and Production) Act was enacted in 1986 to regulate the prospecting for and production of petroleum in Guyana, covering the territorial sea, continental shelf, and exclusive economic zone. This act and the regulations promulgated thereunder identify persons allowed to hold prospecting licenses, establish the process for obtaining prospecting licenses, and specify requirements for further resource development in the event petroleum resources are discovered.

3.1.6. Amerindian Act

The Amerindian Act was enacted in 2006. It provides for the recognition and protection of the collective rights of Amerindian villages and communities, the granting of lands to Amerindian villages and communities, and the promotion of good governance with Amerindian villages and communities. The Ministry of Indigenous Peoples' Affairs oversees implementation of this act. Key aspects of this act include the following:

- This act includes a process for the granting of land. A community can apply for land once they can prove that they have been living on it for at least 25 years.
- The Ministry is not required to approve leasing of titled Amerindian land. The communities are only required to seek the advice of the Minister.
- With respect to the use of scientific research related to Amerindian issues, the researcher must, among other things, submit a copy of any publication containing material derived from the research to the Village Council.
- This act supports the need for the communities to use their natural resources in a way that lends support to the concept of sustainability. Impact assessments are required in accordance with the Environmental Protection Act.
- Amerindians have a legal right to traditional mining with the consent of the Village Council and they must comply with the relevant legislation. With regard to forestry, the Village Council plays an integral role in determining who is allowed to use their land and on what terms.
- The Village Council is empowered to establish rules for their communities and set fines within the legal confines of the law. Money received due to the non-adherence of the rules goes into the Village Council's account, not the government's account.

3.1.7. Natural Resource Fund Act

The Natural Resource Fund Act was enacted in 2019 to establish the National Resource Fund (Fund) to manage Guyana's natural resource wealth in an efficient and effective manner for the present and future benefit of the people and for financing national development priorities, including initiatives aimed at achieving an inclusive green economy. This act empowers the Minister of Finance with the overall management of the Fund, including preparing the Fund's Investment Mandate. The act establishes an Investment Committee, a Macroeconomic

Committee, and a Senior Investment Adviser and Analyst to support the Minister in management of the Fund.

The Bank of Guyana is responsible for operational management of the Fund. A Public Accountability and Oversight Committee was established to ensure that the Fund is managed transparently and to provide an independent assessment of withdrawals from the Fund. Deposits into the Fund are intended to come from Guyana's petroleum revenues, including from royalties, the government's share of profits, and signature bonuses, among others. Revenues from the mining and forestry sectors may also be deposited into the Fund.

3.1.8. Other Resource-Specific National Environmental and Social Laws

Several additional Guyanese environmental laws with more narrowly defined scopes pertain to specific biological or physical natural resources. Other laws that primarily have a public health-related focus may also be relevant to the Project. Several of Guyana's environmental statutes were enacted prior to the Constitution and were subsequently incorporated into the newly formed national legal framework, but most were enacted after 1980. These laws are discussed in the relevant resource/receptor-specific discussions in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources.

3.2. ENVIRONMENTAL PERMITS AND LICENSES

As part of Project implementation, the Project will be required to obtain the following key environmental-related permits:

- Environmental Permit—To undertake the Project, EEPGL is required to obtain an environmental authorization (also commonly referred to as an Environmental Permit) from the EPA. The Application for Environmental Authorisation filed with the EPA on 1 April 2021 initiated this regulatory process. After submission and review of this EIA, the EPA will take into account comments from other agencies, the public's comments, EPA's own review—including support from technical experts, and recommendations from the Environmental Assessment Board in deciding whether and under what conditions to grant EEPGL an environmental authorization for the Project.
- Hazardous Waste Permit—With regard to onshore waste management, an Application for Environmental Authorisation must be submitted to the EPA by the operator of the onshore facility in order to operate a facility that generates, transports, treats, stores, or disposes of hazardous waste. The Application for Environmental Authorisation must be prepared in accordance with the provisions of regulation 17 of the Environmental Protection (Authorisations) Regulations 2000. As such, the vessel owners/operators supporting the Project will be required to obtain authorization for any marine vessels used to transport hazardous wastes to onshore facilities. In addition, vehicle owners/operators will be required

to obtain authorization for any vehicles used to transport hazardous waste from the shore to offsite waste management facilities. For any third-party owned/operated marine vessels or vehicles used to transport hazardous waste from the Project, the environmental authorization will need to be obtained by the third party. Similarly, any environmental authorizations for third-party operated facilities used to manage hazardous waste will be obtained by the owner/operators of such facilities.

3.3. NATIONAL POLICY FRAMEWORK

Guyana's government has articulated national policies on several environmental and social topics that are relevant to the Project. This section provides an overview of the key government environmental and social policies applicable to the Project.

3.3.1. Low Carbon Development Strategy

In June 2009, the Government of Guyana announced the Low Carbon Development Strategy (LCDS). The strategy was re-adopted by the government after the 2020 elections. The LCDS aims to protect and maintain forests in an effort to reduce global carbon emissions and at the same time attract payments from participating developed countries for the climate services that the forests provide. In 2013, the LCDS was updated to focus on two main goals: (1) transforming the national economy to deliver greater economic and social development by following a low-carbon development path while simultaneously combating climate change; and (2) providing a model for how climate change can be addressed through low-carbon development in developing countries (Office of the President 2016). The LCDS identifies Reducing Deforestation and Forest Degradation Plus as the primary mechanism for achieving the goals of the strategy.

3.3.2. National Environmental Action Plan

Guyana's National Environmental Action Plan (NEAP) articulates the government's approach to managing the environment from the perspective of economic development. The NEAP considers the issues of environmental management, economic development, social justice, and public health to be inextricably linked. It identifies deforestation, pollution, and unregulated gold mining as growing environmental concerns, and identifies private-sector investment as one of the primary opportunities to generate the necessary capacity within Guyana to (1) provide an appropriate level of public services to its citizens; (2) reduce and/or eliminate the avoidable environmental degradation that occurs when resource development occurs in a regulatory vacuum; and (3) reduce unsustainable uses of natural resources due to the socioeconomic pressures of widespread poverty.

The NEAP relates to the Project in several ways. It identifies the coastal zone within which Project activities will occur as an area in need of focused management action due to the concentrated human population along the coast and the susceptibility of the coastal environment to both natural and human-induced degradation. Additionally, it identifies private-sector-led development projects as a mechanism to build capacity and ultimately support more

responsible environmental management. Finally, it identifies petroleum resources as a potential target for development.

3.3.3. Integrated Coastal Zone Management Action Plan

Guyana's Integrated Coastal Zone Management (ICZM) process is an ongoing initiative to promote the wise use, development, and protection of coastal and marine resources; enhance collaboration among sectorial agencies; and promote economic development. In 2000, after 2 years of study, the ICZM committee produced an ICZM Action Plan, which was approved by the Cabinet in 2001.

The ICZM Action Plan addresses policy development, analysis and planning, coordination, public awareness building and education, control and compliance, monitoring and measurement, and information management (EPA 2000). Other coastal zone–related tasks currently being undertaken by the government include strengthening the institutional setup for ICZM, conducting a public awareness campaign to increase public understanding of the vulnerability of the coastal zone to sea-level rise and climate change, and creating a database of coastal resources to facilitate improved ICZM. Currently, the EPA is mandated to coordinate the ICZM program and coordinate the development of the ICZM Action Plan through the ICZM Committee.

Under the Caribbean Planning for Adaptation to Climate Change project (CARICOM 2015), Guyana has also conducted a socioeconomic assessment of sea-level rise as part of a wider vulnerability assessment and developed a Climate Change Action Plan, with subsequent draft action plans under development (Government of Guyana 2001; Ministry of the Presidency 2015; Shah 2019).

3.3.4. Guyana's National Biodiversity Strategy and Action Plan

Guyana's current National Biodiversity Strategy and Action Plan (NBSAP) was formally adopted in 2015 and is the third iteration of the NBSAP. It establishes the national vision for biodiversity, which is to sustainably utilize, manage, and mainstream biodiversity by 2030, thereby contributing to the advancement of Guyana's bio-security, and socioeconomic and low-carbon development. It is intended to guide national policy with respect to biodiversity through 2020. It recognizes the importance of biodiversity to the growing ecotourism industry and other economic sectors. The NBSAP sets forth nine strategic objectives intended to promote conservation and sustainability on a national scale, improve biodiversity monitoring, harmonize legal and policy-based mechanisms across all levels of government to support biodiversity conservation, and prioritize funding to meet these objectives.

3.3.5. Local Content Policy for the Development of Guyana's Petroleum Economy

Guyana Petroleum Sector: Realising Local Content Benefits and Value Retention from Guyana's Petroleum Resources Local Content Policy was released in January 2020 (Ministry of the Presidency and Department of Energy 2020). It established local content policy as the most

important driver of economic development from Guyana's petroleum industry, and provides fair and adequate opportunity of Guyanese to support the oil and gas sector where capability exists. Although it provides for first considering Guyanese goods and services in some contexts, it also seeks to attract foreign investment. The objectives are to be fit-for-purpose; promote education, inclusion, and advancements; localize supply chains; align with good international oilfield practices; grow supplier competencies to become world-class and develop export potential; retain value in the Guyanese economy; enhance other sectors of the economy; build and enhance institutional capacity; invest in physical utilities, infrastructure, and facilities; invite partnering; and develop world-class capacity in key state institutions to implement the policy. In February 2021, the Ministry of Natural Resources released a revised draft *Local Content Policy for the Development of Guyana's Petroleum Economy* (Ministry of Natural Resources 2021) with its focus being:

- A guide toward a national strategy for economic development;
- A mechanism to create value beyond the sector;
- Grounded in the objectives of a realistic assessment of our resource and capabilities;
- Adaptive to the energy mix and transition objective towards a local carbon economy; and
- Integrated into the procurement strategy of the national economy.

It is anticipated that an updated draft policy, legislation, implementation mechanism, and monitoring and reporting guidance will be simultaneously released for further public consultation in the fourth quarter of 2021.

3.4. INTERNATIONAL CONVENTIONS AND PROTOCOLS

Guyana is signatory to a number of international agreements and conventions relating to environmental management and community rights, although not all of these agreements have been translated into national legislation. The key agreements and conventions potentially relevant to the Project, to which Guyana has acceded or is a signatory, are summarized in the relevant resource/receptor-specific discussions in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources.

Guyana is a member state of two organizations that administer multiple international treaties and conventions: the International Labour Organization (ILO) and the International Maritime Organization (IMO). The ILO has established eight fundamental conventions that provide certain general protections to workers in signatory states, such as the right to organize, standards for remuneration, restrictions on child labor (including minimum ages to work), and protection from forced labor. In addition to these fundamental agreements, Guyana is signatory to several specific agreements that will govern certain specific aspects of the Project as they relate to labor.

The IMO is a similar organization whose member states have agreed to one or more conventions related to maritime activities. These include three key conventions (the International Convention for the Safety of Life at Sea, the International Convention for the Prevention of Pollution from Ships 1973, as modified by the Protocol of 1978, and the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers) as well as several other agreements concerning more specific aspects of maritime activity, such as safety and security at sea, maritime pollution, and liability for maritime casualties. One of these other agreements administered by the IMO is the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1992, often referred to as FUND92 or FUND. Guyana is an observer nation under the 1992 FUND Convention, which established the International Oil Pollution Compensation Fund and the protocol for the International Oil Pollution Supplementary Fund. The Guyana Maritime Administration Department manages compliance with the requirements of the IMO agreements to which Guyana is a signatory, with technical assistance from the IMO's Regional Maritime Advisory Office in Port of Spain, Trinidad.

Guyana also belongs to other international organizations such as the Organization of American States, the International Monetary Fund, and the Caribbean Community.

To highlight Guyana's adherence to international standards and guidelines relevant to the oil and gas sector, in May 2010, the country announced its commitment to the implementation of the Extractive Industries Transparency Initiative (EITI) and in September 2015, the country recommitted its support to the ILO.

In October 2017, Guyana became the 53rd candidate country in the EITI. EITI is a global standard to promote the open and accountable management of extractives resources; it seeks to strengthen government and company systems, inform the public, and promote industry understanding. It was founded in 2003 with an aim of protecting the interests of developing or frontier countries such as Guyana (EITI 2021).

To gain membership status, Guyana was required to assemble a multi-stakeholder group, which included equal representation from the government, civil society, and industry. The goal is to develop a consensus reporting system that applies to all extractive companies operating in the country and to make that report public every year. These reports will be audited by a third party and distributed publicly for review. Guyana's most recent report and a workplan for calendar years 2021 and 2022 were published in April 2021.

In collaboration with the Government of Guyana, in December 2017 EEPGL was the first energy company to release its Petroleum Agreement with the Government of Guyana. The Stabroek Block Petroleum Agreement provides transparent information on revenue share, cost recovery, royalties, taxes, signing bonus, and other topics of interest to the public.

Table 3-1: Legislation, Policies, or Treaty Commitments—All Resources/Receptors

Title	Objective	Relevance to the Project	Resource/Receptor
Legislation			
Environmental Protection Air Quality Regulations, 2000	Requires environmental authorisation for industrial facilities emitting air contaminants. Establishes that the EPA shall at any time after the commencement of the Regulations, establish limits for any of the contaminants specified in the regulation.	Applicable to Project sources of emissions to air (although no limits have yet been established by the EPA).	Air Quality, Climate, and Climate Change
Environmental Protection Noise Management Regulations, 2000	Establishes general provisions for noise avoidance and restrictions from multiple commercial and industrial sources, including sound-making devices, equipment, tools, and construction activities, and includes permitting and reporting requirements. Authorizes EPA to set specific permissible noise levels in the future.	Regulated facilities include any offshore installation and any other installation, whether floating or resting on the seabed.	Sound
Environmental Protection Water Quality Regulations, 2000	Enables the EPA to set effluent standards for discharges to inland or coastal waters or land of Guyana (none have been issued in final form to date), establishes authorization requirements for discharges to inland or coastal waters, and requires holders of such authorizations to establish effluent sampling points as required by the EPA.	Establishes a basis for regulating discharge of listed substances to inland or coastal waters, which could include substances used as part of the Project.	Water Quality

Title	Objective	Relevance to the Project	Resource/Receptor
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013; the Wild Birds Protection Act, 1987; and the Species Protection Regulations, 1999)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a framework to address the national goals for wildlife protection, conservation, and management. The Act also provides recommendations on measures for the protection of threatened ecosystems and habitats, and advises on measures for conservation of biological diversity.	Protected Areas and Special Status Species; Coastal Habitats; Coastal Wildlife; Seabirds; Marine Mammals; Riverine Mammals; Marine Turtles; Marine Fish; Marine Benthos; Ecological Balance and Ecosystems
Protected Areas Act, 2011	Provides for protection and conservation of Guyana's natural heritage and natural capital through a national network of protected areas; the maintenance of ecosystem services of national and global importance, including of climate regulation; and the fulfilment of Guyana's international environmental responsibilities. This act also allowed for the creation of the Protected Areas Commission to oversee the management of this network. It highlights the importance of maintaining ecosystem services of national and global importance and public participation in the conservation of protected areas. It establishes a protected-areas trust fund to ensure adequate financial support for maintenance of the network. Other functions of this act include promoting national pride in and encouraging stewardship of Guyana's natural heritage; recognizing the conservation efforts and achievements of Amerindian	Shell Beach, which is a coastal area subject to potential impact from a Project unplanned event (i.e., oil spill), was identified as one of the five priority areas for establishment of protected areas in Guyana and was designated a protected area with the passage of the Protected Areas Act in 2011.	Protected Areas and Special Status Species

Title	Objective	Relevance to the Project	Resource/Receptor
	villages and Amerindian communities; and promoting the recovery and rehabilitation of vulnerable, threatened, and endangered species.		
Natural Resource Fund Act (2019)	Establishes the National Resource Fund to manage the natural resource wealth of Guyana for the present and future benefit of the people and for the sustainable development of the country. The act also outlines governance and oversight mechanisms of the fund.	Provides for revenues from the Project to be deposited into the fund and used to finance national development, including initiatives aimed at achieving the government's vision of an inclusive green economy.	Socioeconomic Conditions
Local Content Act (2021)	Provides for the implementation of local content obligations for petroleum operations or related activities in the petroleum sector.	Directly influences Guyanese service provision and employment in the petroleum sector. Includes requirements to develop and submit local content plans, as well as auditing and reporting. Also establishes an official register of Guyanese nationals and Guyanese companies for employment and procurement, and provides detailed annual local content targets for certain sectors and sub-sectors. Establishes a Local Content Advisory Committee to provide recommendations and collaborate on strategic initiatives related to local content.	Socioeconomic Conditions; Employment and Livelihoods
Occupational Safety and Health Act (1997) Cap. 99:06.	Legally defines the responsibilities of workers and management with respect to keeping workplaces safe.	Generally applies to Project workers and Project-related activities.	Employment and Livelihoods; Community Health and Wellbeing
Food and Drug Regulations (Food and Drug Act, 1971) Cap. 34:03.	Regulates the sale, advertisement, preparation, and handling of food products; regulates the	Governs the preparation of food and provision of medications at Project facilities.	Employment and Livelihoods; Community Health and Wellbeing

Title	Objective	Relevance to the Project	Resource/Receptor
	manufacture, advertisement, trade, and administration of pharmaceuticals; provides the Ministry of Health authority to inspect facilities to establish compliance with sanitation standards.		
Prevention of Discrimination Act (1997) Cap. 99:08.	Provides for the elimination of discrimination in employment, training, recruitment, and membership in professional bodies and the promotion or equal remuneration to men and women in employment who perform work of equal value.	Prevents discrimination in employment practices.	Employment and Livelihoods
National Insurance and Social Security Act (1969) Cap. 36:01.	Establishes a system of national insurance and social security providing pecuniary payments by way of old age benefit, invalidity benefit, survivor's benefit, sickness benefit, maternity benefit, and funeral benefit, and to substitute for compensation system of insurance against injury or death caused by accident arising in the course of employment or resulting from disease due to the nature of employment; establishes a National Insurance Fund.	Provides the overarching framework for workers' insurance and other benefits.	Employment and Livelihoods
Employment of Young Persons and Children Act. Cap. 99:01.	Seeks to implement certain conventions relating to the employment of young persons and children.	Restricts the ages of young persons who may be employed by the Project.	Employment and Livelihoods
Termination of Employment and Severance Pay Act (1997, 1999) Cap. 96:01.	Makes provision for the conditions governing termination of employment and grant of	Governs payments to employees or the termination of employment. This could be relevant to contractors and sub-contractors to the Project.	Employment and Livelihoods

Title	Objective	Relevance to the Project	Resource/Receptor
	redundancy or severance payment to employees.		
Health Facilities Licensing Act (2007) and Health Facilities Licensing Regulations (2008)	Under the act, all health facilities must be licensed by the Minister of Health. The act also provides for inspectors who are authorized to enter any facility and conduct inspections. Offenses are outlined with fines and imprisonment upon summary conviction. Importantly, the act also provides for the Minister to make regulations related to licenses, renewals, and standards for health facilities; record keeping; and prescribing and governing the construction, establishment, location, equipment, maintenance, repair of, additions and alterations to, and operations of health facilities. Licensing regulations address licensing and operation of health facilities including governance, health and safety, hygiene, staffing, policies and procedures, and oversight / quality assurance requirements.	Sets the requirements for health facilities at which services would be available to Project workers.	Community Health and Wellbeing
Guyana Shipping Act (1998) Cap. 49:01.	Establishes the framework for the regulation of vessels and sets out MARAD and its functions.	MARAD is the principal regulator for vessels operating in the marine environment and all vessels associated with the Project operating within Guyana waters will fall under the purview of MARAD.	Marine Use and Transportation
Maritime Zones Act (2010) Cap. 63:01.	Incorporates certain provisions of the United Nations Convention on the Law of the Sea and the United Nations Educational, Scientific and Cultural Organization Convention on the Protection of the Underwater	Provides for rights and regulation of activities within the various maritime zones, including the territorial sea and exclusive economic zone, and addresses the protection and preservation of the	Marine Use and Transportation

Title	Objective	Relevance to the Project	Resource/Receptor
	Cultural Heritage, to provide for marine scientific research, maritime cultural area, eco-tourism, marine parks and reserves and mariculture, the protection and preservation of the marine environment and for related matters.	marine environment, including pollution.	
Sea Defence Act (1953, 1988, 1992) Cap. 64:03.	Aims to make better provision for the maintenance and construction of sea defenses in Guyana, which includes manmade structures as well as natural defenses.	Covers the protection of mangroves, which serve as a natural sea defense mechanism; there are fines and penalties for the unpermitted destruction of mangroves. Relevant to the Project in the unlikely event of an oil spill reaching the shore and causing mangrove damage.	Social Infrastructure and Services, Ecosystem Services
Ministry of Health Act (2005)	Outlines the responsibilities and functions of the Ministry of Public Health, including responsibilities in relation to health care facilities.	Generally applies to health care services supplied to Project workers.	Social Infrastructure and Services
Environmental Protection Hazardous Waste Regulations (2000)	Establishes requirements for generating, handling, and disposing of hazardous waste as well as penalties for violations of these requirements.	Identifies wastes subject to regulation, including several types of waste that could be generated as part of the Project.	Waste Management Infrastructure Capacity
National Trust Act (1972) Cap. 20:03.	Stewardship of historic resources and places of cultural significance.	Governs the management of any building, structure, object, or other manmade or natural feature that is of historic or national cultural significance that could be impacted by the Project. Includes shipwrecks and other marine features. Would also apply to the Project in the event of a chance find, in which case the act would require EEPGL to work cooperatively with the	Cultural Heritage

Title	Objective	Relevance to the Project	Resource/Receptor
		National Trust of Guyana to manage any resources discovered.	
Maritime Zones Act (2010) Cap. 63:01.	Incorporates certain provisions of the United Nations Convention on the Law of the Sea and the United Nations Educational, Scientific and Cultural Organization Convention on the Protection of the Underwater Cultural Heritage, to provide for marine scientific research, maritime cultural area, eco-tourism, marine parks and reserves, the protection and preservation of the marine environment and for related matters.	Relevant to the Project as it provides for rights and regulation of various maritime zones, including the territorial sea, and the discharge of harmful substances and hazardous waste, as physical movements and/or changes in water quality or ecological conditions could affect underwater and/or coastal cultural heritage.	Cultural Heritage
Forests Act (2009) Act. No. 6 of 2009	Consolidates the law relating to forests and makes provisions for sustainable forest management and forest conservation.	Covers mangroves, which are classified as a forest type and subject to protection measures under the Act. Mangrove ecosystem makes up a significant portion of Guyana's coastal zone, and could potentially be affected in the unlikely event of an oil spill event which reaches the shore.	Ecosystems Services
Amerindian Act (2006) Cap. 29:01.	Provides for the recognition and protection of the collective rights of Amerindian villages and communities, the granting of lands to Amerindian villages and communities, and the promotion of good governance with Amerindian villages and communities.	Within the broad context of protection of the collective rights of Amerindian villages, this could include the right of use of coastal resources for traditional and subsistence activities, which could be affected in the unlikely event of an oil spill from the Project.	Indigenous Peoples
Fisheries Act, 2002	Regulates fishing and related activities in Guyana territorial waters.	Section 33(1) of the Fisheries Act authorizes the prohibition and/or regulation of deposition or discharge of substances harmful to fish.	Marine Fish

Title	Objective	Relevance to the Project	Resource/Receptor
Standards			
Guyana Standard, Guidelines for Noise Emission into the Environment, 2010	Establishes standard used for monitoring of noise emission into the environment; sets permissible noise levels for residential, commercial, industrial, institutional, educational, construction, transportation, and recreational receptors (day and night).	Relevant to Project-related noise levels that could be perceived by human receptors (onshore or nearshore activities)	Sound
Guidance			
Joint Nature Conservation Committee Guidelines for Minimising the Risk of Injury and Disturbance to Marine Mammals from Seismic Surveys (JNCC 2017)	Provides guidelines for procedures to reduce the risk of injury to marine mammals from geophysical survey activities.	Although the JNCC guidelines are voluntary, they are widely recognized as a global best practice in the oil and gas industry for managing the potential adverse effects of seismic surveys on marine mammals, and will be applicable to vertical seismic profiles conducted on any of the development wells.	Sound
Policies and Strategies			
Occupational Safety and Health Policy (GoG 2018)	Aims to promote and improve the quality of life of workers by preventing social and economic losses, work-related accidents, and injury to health by eliminating hazards, reducing the number of accidents, and injuries, and combating stresses and incidence of occupational diseases. The policy orients the Ministry of Social Protection to modernize its policies and procedures. Implementation is supported by the International Labour Organization.	Applies to all categories of workers and workplaces, in all sectors, including the Project and Project workers.	Employment and Livelihoods

Title	Objective	Relevance to the Project	Resource/Receptor
Health Vision 2020: National Health Strategy for Guyana (2013)	Creates an enabling framework for the integrated delivery of quality, effective, and responsive health services and prevention measures to improve the physical, mental, and social wellbeing of all people in Guyana.	Seeks to improve service delivery; managing communicable and non-communicable diseases; and improving health outcomes.	Community Health and Wellbeing
National Solid Waste Management Strategy (Under Development)	Guides the Government of Guyana's agenda on waste collection, transportation, and disposal; goals include improving the waste management infrastructure, enforcing existing legislation, and promoting waste-to-energy initiatives. Will inform the country's integrated efforts at converting waste material into useful resources and aims to ensure their full utilization and eventual exploitation as by-products. Currently under development.	Once the strategy is approved, it is expected to apply to the collection, transportation, and disposal of Project-generated waste.	Waste Management Infrastructure Capacity
International Agreements Signed / Acceded by Guyana			
Paris Agreement (under the United Nations Framework Convention on Climate Change [UNFCCC])	Promotes international cooperation to limit average temperature increases and resulting changes in climate, and international cooperation to adapt to these impacts.	Provides a framework for possible future regulation of greenhouse gas (GHG) emissions within Guyana's territory (maritime and land) and for establishing national policy regarding adaptation to climate change.	Air Quality, Climate, and Climate Change
Vienna Convention on the Protection of the Ozone Layer (Guyana acceded in 1993)	Provides a framework for the protection of the ozone layer.	Establishes measures for protecting the ozone layer.	Air Quality, Climate, and Climate Change
Montreal Protocol on Substances that Deplete the Ozone Layer (Guyana acceded in 1993)	A protocol to the Vienna Convention designed to protect the ozone layer by phasing out the production of numerous substances	Prohibits the use of several groups of halogenated hydrocarbons that may deplete the ozone layer.	Air Quality, Climate, and Climate Change

Title	Objective	Relevance to the Project	Resource/Receptor
	that are responsible for ozone depletion.		
International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) (Guyana acceded in 1997)	Regulates various forms of marine pollution, including oil and fuel, noxious liquid, hazardous substances, sewage, garbage, air emissions, and ballast water.	Applies to the handling and disposition of regulated substances from Project drill ships, FPSO, and support vessels.	Water Quality
		Impacts the handling and disposition of regulated substances from Project drill ships, FPSO, and support vessels. Release of pollution from ships can change and/or compromise the functioning of ecosystems, potentially having implications for altering ecosystem services.	Ecological Balance and Ecosystems
International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004	Controls the release of ballast water in national waters for all vessels.	Applies to the management of ballast water from Project drill ships, FPSO, and support vessels.	Water Quality
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (Guyana acceded and ratified in 2010)	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection for the marine environment, especially from possible pollution.	Protected Areas and Special Status Species; Seabirds; Marine Mammals; Riverine Mammals; Marine Turtles; Marine Fish; Marine Benthos; Ecological Balance and Ecosystems
Protocol on Specially Protected Areas and Wildlife (Guyana acceded and ratified in 2010)	Protocol supplementing and supporting the Cartagena Convention. Requires signatories to adopt an ecosystem approach to conservation. Provides mechanism for compliance with the Convention on Biological Diversity.	Elaborates on the wildlife goals established in the Cartagena Convention and Convention on Biological Diversity.	Protected Areas and Special Status Species; Coastal Habitats; Marine Turtles
		Elaborates on the wildlife goals established in the Cartagena Convention and Convention on Biological Diversity. This protocol relates to efforts to legally recognize and preserve intact ecosystems by Guyana, giving special importance to large areas needed to maintain ecosystem	Ecological Balance and Ecosystems

Title	Objective	Relevance to the Project	Resource/Receptor
		function and balance, including the SBPA.	
Convention on Biological Diversity (Guyana signed in 1992 and ratified in 1994)	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Encourages Project design and execution to protect and conserve biological diversity.	Protected Areas and Special Status Species; Coastal Habitats; Coastal Wildlife; Seabirds; Marine Mammals; Riverine Mammals; Marine Turtles; Marine Fish; Marine Benthos; Ecological Balance and Ecosystems; Ecosystem Services
International Maritime Organization Agreements (IMO)	The IMO administers a number of global environmental conventions, agreements, and commitments such as International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978, on ship-generated wastes; Ballast Water Convention; London Convention.	Contracting parties to the convention are also required to protect and preserve rare or fragile ecosystems and habitats of depleted, threatened, or endangered species; and develop technical and other guidelines for the planning and environmental impact assessments of important development projects.	Marine Turtles; Marine Fish
International Convention for the Safety of Life at Sea (1974) (Guyana acceded in 1997)	Specifies minimum standards for the construction, equipment, and operation of vessels with respect to their safety; allows governments of participating states to inspect vessels flagged in other participating states to ensure compliance.	Affects construction, operation, and equipment on board the drill ships, FPSO, installation vessels, and support vessels.	Marine Use and Transportation
Convention on the International Regulations for Preventing Collisions at Sea (1972) (Guyana acceded in 1997)	Officially recognizes the importance of traffic separation in the marine environment and codifies basic measures to accommodate traffic separation, including safe speed, signalling conventions, and general vessel conduct.	Governs maritime operation of drill ships, FPSO, installation vessels, and support vessels.	Marine Use and Transportation

Title	Objective	Relevance to the Project	Resource/Receptor
International Convention on Standards of Training, Certification and Watchkeeping (1978) (Guyana acceded in 1997)	Obligates crews operating vessels flagged in signatory states to adhere to minimum standards relating to training, certification, and watchkeeping; requires signatory states to submit detailed information to the International Maritime Organization concerning administrative measures taken to ensure compliance with the convention.	Applies to required capabilities of crew on board the drill ships, FPSO, installation vessels, and support vessels, and provides for inspection by authorities to ensure compliance.	Marine Use and Transportation
Convention on Facilitation of International Maritime Traffic (1965) (Guyana acceded in 1998)	Prevents unnecessary delays in maritime traffic arising from burdensome documentation requirements and establishes uniform formalities and other procedures to permit transboundary maritime commerce and travel.	Facilitates entry of drill ships, FPSO, installation vessels, and support vessels into Guyana.	Marine Use and Transportation
IMO International Maritime Dangerous Goods Code (2018 edition)	Governs maritime transport of wastes worldwide; addresses classifications of dangerous goods, packing and tank provisions, consignment procedures, construction and testing of packaging, IBCs, portable tanks, and transport operations.	Applies to all marine vessels that will transport wastes generated as part of the Project.	Waste Management and Infrastructure Capacity
Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal (1989)	Identifies conditions on the import and export of hazardous wastes, including requirements for notice, consent, and tracking for movement of wastes across international boundaries.	Would apply to the Project only if hazardous waste generated in Guyana is disposed outside Guyana. Currently, the convention is not relevant, as EEPGL does not import or export hazardous wastes. Guyana acceded in 2001.	Waste Management and Infrastructure Capacity

Title	Objective	Relevance to the Project	Resource/Receptor
United Nations Educational, Scientific and Cultural Organization Convention on the Protection of the Underwater Cultural Heritage (2001) (Guyana ratified in 2014)	Protects “all traces of human existence having a cultural, historical, or archaeological character” that have been underwater for over 100 years.	Would apply to any shipwrecks or other submerged cultural heritage in the Project AOI.	Cultural Heritage
United Nations Declaration on the Rights of Indigenous Peoples (2007)	A comprehensive statement addressing the rights of Indigenous Peoples. It emphasizes the rights of Indigenous Peoples to maintain and strengthen their own institutions, cultures, and traditions and to pursue their development in keeping with their own needs and aspirations. Further, it addresses both individual and collective rights, cultural rights and identity, rights to education, health, employment, and language, among others.	Guyana’s adoption of the Declaration creates an expectation for the Project to include engagements with Indigenous Peoples and take necessary measures to respect their rights.	Indigenous Peoples
American Declaration on the Rights of Indigenous Peoples (Organisation of American States) (2016)	Offers specific protection for Indigenous Peoples in North America, Mexico, Central and South America, and the Caribbean. Affirms the right of self-determination; rights to education, health, self-government, culture, lands, territories, and natural resources; and it includes provisions that address the particular situation of Indigenous Peoples in the Americas, including protections indigenous women and children, and those living in voluntary isolation, among others.	Guyana’s adoption of the Declaration creates an expectation for the Project to include engagements with Indigenous Peoples and take necessary measures to respect their rights.	Indigenous Peoples

Note: The Consultants have not identified any legislation, policies, or treaty commitments that focus specifically on marine geology and sediments. No legislation, policies, or treaty commitments are specifically and directly relevant to the assessment of potential impacts on land use for the Project.

3.5. EEPGL's Operations Integrity Management System

ExxonMobil (EEPGL's parent organization) and its affiliates (including EEPGL) are committed to conducting business in a manner that is compatible with the environmental and socioeconomic needs of the communities in which it operates, and that protects the safety, security, and health of its employees, those involved with its operations, its customers, and the public. These commitments are documented in its Safety, Security, Health, Environmental, and Product Safety policies. These policies are put into practice through a disciplined management framework called the Operations Integrity Management System (OIMS).

ExxonMobil's OIMS Framework establishes common expectations used by ExxonMobil affiliates worldwide for addressing risks inherent in its business. The term "Operations Integrity" is used to address all aspects of its business that can impact personnel and process safety, occupational safety, security, occupational health, and environmental performance.

Application of the OIMS Framework is required across all ExxonMobil affiliates, with particular emphasis on design, construction, and operations. Management is responsible for ensuring that management systems that satisfy the OIMS Framework are in place. Implementation is consistent with the risks associated with the business activities being planned and performed. Figure 3.5-1 provides a high-level description of the OIMS Framework and its 11 essential elements.

Figure 3.5-1: Operations Integrity Management System

Section 2.3 of the Project's Environmental and Socioeconomic Management Plan (Volume III of the regulatory submittal) includes a discussion of the key elements of EEPGL's occupational safety and health programs that will be used during the Project life cycle. These key elements stem from the expectations and requirements established by OIMS to identify and manage occupational safety and health risks associated with the Project's operations.

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4. METHODOLOGY FOR PREPARING THE ENVIRONMENTAL IMPACT ASSESSMENT

The purpose of this EIA is to assess the potential physical, biological, and socioeconomic (including social, economic, community health, and cultural) impacts of the Project. This chapter provides a summary of the approach and methodology used to assess the potential impacts associated with the Project. The EIA has been prepared in compliance with the Guyana Environmental Protection Act (as amended in 2005), the Environmental Protection (Authorisation) Regulations (2000), the Environmental Impact Assessment Guidelines—Volume 1, Version 5 (EPA 2004), the Environmental Impact Assessment Guidelines—Volume 2, Version 4 (EPA/EAB 2000), other applicable Guyana regulations, good international oilfield practice, and EEPGL's corporate standards, and in accordance with the Consultants' standard practices.

This chapter also describes the process used to conduct the EIA. The EIA was prepared to provide an independent, science-based evaluation of the potential impacts associated with the development drilling, installation, production operations, and decommissioning stages of the Project. The EIA is also the primary mechanism for sharing those findings with stakeholders and decision-makers so they can make informed decisions regarding the potential benefits and impacts of the Project, as well as the measures proposed to enhance these benefits and mitigate these impacts.

4.1. TYPES OF POTENTIAL IMPACTS

The EIA has been undertaken following a systematic process that evaluates the potential impacts that the Project could have on physical, biological, and socioeconomic resources/receptors, and that identifies measures EEPGL will take to avoid, reduce, and/or remedy those impacts.[1] For the purposes of the EIA, an impact is defined as any alteration of existing conditions (adverse or beneficial) caused directly or indirectly by the Project. Under the provisions of the Environmental Protection Act (as amended in 2005), potential adverse[2] effects would include the following:

> "(i) impairment of the quality of the natural environment or any use that can be made of it;
>
> (ii) injury or damage to property or to plant or animal life;
>
> (iii) harm or material discomfort to any person;
>
> (iv) an adverse effect on the health of any person;
>
> (v) impairment of the safety of any person;

[1] EEPGL will also establish measures to enhance and/or support access to Project-related benefits.

[2] The Environmental Protection Act refers to "adverse effects" but the Environmental Impact Assessment Guidelines Volume 1—Rules and Procedures for Conducting and Reviewing EIAs, Version 5 (EPA 2004) refers to "negative impacts". Globally, EIAs frequently use the term "impacts" and "effects" interchangeably. Accordingly, both terms "adverse effects" and "negative impacts" are used interchangeably in this EIA, but for the purposes of this EIA both terms are defined according to the definition for "adverse effects" contained in the Act.

(vi) rendering any property or plant or animal life unfit for use by human or unfit for its role in the ecosystem;

(vii) loss of enjoyment of normal use of property; and

(viii) interference with the normal conduct of business."

Although the Environmental Protection Act does not define positive impacts (i.e., Project benefits), examples of potential positive impacts include increased employment opportunities and revenue sharing with the Government of Guyana.

The EIA considers the possibility of both direct and indirect impacts of the Project.

4.2. APPROACH TO IMPACT ASSESSMENT

Information on potential impacts, including potential cumulative impacts related to the Project, was obtained by the Consultants from various primary and secondary sources, including consultations and key informant interviews with government entities and other stakeholders (see Section 4.7, Stakeholder Engagement); field studies in the Project Area of Influence (AOI); environmental impact assessments for other similar projects in Guyana and worldwide; and scientific literature.

The key stages for the EIA approach are:

- Screening
- Scoping
- Assessment of Existing Conditions
- Project Description and Interaction with Design and Decision-Making Process
- Stakeholder Engagement
- Assessment of Impacts and Identification of Mitigation Measures, as appropriate

4.3. SCREENING

The first stage of the EIA process involved the EPA screening the Project to determine the appropriate level of analysis to support the application submitted by EEPGL on 1 April 2021. The EPA screens projects based on the information provided in the application and determines the depth of environmental assessment / type of document required to support the review of the application.

Based on the results of its screening assessment, the EPA can determine that the information included in the application is sufficient to support a permitting decision, or it can require a Strategic Environmental Assessment, Environmental Management & Assessment Plan, and/or an EIA. In this case, the EPA determined that the Project could result in potentially significant impacts and, in accordance with the Environmental Protection Act (as amended in 2005), indicated in a public notice dated 9 May 2021 that an EIA would be required before an environmental authorization can be granted. In a letter dated 28 June 2021, the EPA approved the Consultant team to undertake the EIA.

4.4. SCOPING

The key objectives of scoping are to:

- Identify key sensitivities and those Project actions having the potential to cause or contribute to significant impacts on physical, biological, and socioeconomic resources/receptors;
- Identify potential concept design and technology alternatives for the Project;
- Obtain stakeholder views through consultation; and
- Help inform the Terms and Scope for the EIA through consultation to aid in focusing the EIA process and output on the key issues. The Terms and Scope describes the scope and technical approach for the EIA and the key issues to be considered in the EIA.

Following EEPGL's submittal of the application, a notice of the application was published 9 May 2021. This initiated a 28-day Public Notification Period, during which the public had the opportunity to provide comments on the application and forthcoming Terms and Scope. The EPA hosted a series of scoping consultation meetings to aid in the development of the Terms and Scope (see Table 4.4-1). The objectives of the meetings were to provide stakeholders with information about the Project and the initially identified potential environmental and socioeconomic impacts of the Project and to allow the public and government agencies to provide feedback that would inform the development of the Terms and Scope. This included feedback on the key issues to be addressed as part of the Terms and Scope development and eventual EIA process.

Table 4.4-1: Scoping Consultation Meetings (2021)

Region	Town	Location	Date, Time
All Regions	NA	Virtual meetings, hosted on Zoom	27 May, 13:00 GYT
			27 May, 18:00 GYT
Region 6	No. 66 Village	Fishing Cooperative	28 May, 09:00 GYT
Region 1	Mabaruma	Mabaruma Primary School	31 May, 10:00 GYT
All Regions	NA	Virtual meetings, hosted on Zoom	2 June, 10:00 GYT
			2 June, 19:00 GYT
Region 4	Georgetown	Umana Yama	4 June, 14:00 GYT

GYT = Guyana time; NA = not applicable

The EPA and the Consultants jointly considered the concerns, issues, and suggestions received during the public scoping consultation meetings (see Table 4.7-5). On 10 September 2021, the EPA issued the *Final Terms and Scope for Yellowtail Development Environmental Impact Assessment Study* (referred to herein as the "Terms and Scope") to guide the undertaking of the EIA.

4.5. ASSESSMENT OF EXISTING CONDITIONS

The description of existing physical, biological, and socioeconomic conditions provides information on resources/receptors identified during scoping as having the potential to be significantly impacted by the Project.

The description of existing conditions is aimed at providing sufficient detail to meet the following objectives:

- Identify the key conditions and sensitivities in the Project AOI;
- Provide a basis for extrapolation of the current situation, taking into consideration natural variability, and development of future scenarios without the Project;
- Provide data to aid in the prediction and evaluation of potential impacts of the Project;
- Understand stakeholder concerns, perceptions, and expectations regarding the Project;
- Inform development of appropriate mitigation measures; and
- Provide a benchmark to inform assessments of future changes and of the effectiveness of mitigation measures.

Field studies conducted to document existing conditions for the EIA are described in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources.

4.6. PROJECT DESCRIPTION AND INTERACTION WITH DESIGN AND DECISION-MAKING PROCESS

The interaction between the EIA team and the design and decision-making process was one of the key areas in which the EIA influenced how the Project will be developed. It included involvement in defining the Project and identifying those activities with the potential to cause physical, biological, or socioeconomic impacts. Project planning, decision-making, and refinement of the Project description continued throughout the assessment process in view of identified potential impacts and proposed mitigation measures, and incorporating design refinements based on the assessment, permitting, and operation of earlier offshore development projects. During the EIA process, there was extensive communication between the impact assessment team and the Project design team with regard to identifying alternatives, potential impacts, and mitigation measures.

4.7. STAKEHOLDER ENGAGEMENT

Stakeholder engagement has been (and continues to be) conducted to provide information about the Yellowtail Project to the public and interested stakeholders, and to support the development of the EIA and associated Environmental and Socioeconomic Management Plan (ESMP). The objectives of the Project's stakeholder engagement activities are to:

- Identify Project stakeholders and understand their interests and concerns in relation to Project activities, and incorporate such interests and concerns into the EIA and ESMP development processes and, if appropriate, the Project design;

- Promote the development of respectful and open relationships between stakeholders and EEPGL during the Project life cycle (i.e., 20 years or more);
- Provide stakeholders with timely information about the Project in ways that are appropriate to their interests and needs, and also appropriate to the level of expected risks and potential adverse impacts;
- Satisfy regulatory requirements and EEPGL expectations for stakeholder engagement; and
- Record feedback and address any grievances that may arise from Project-related activities through a formal feedback mechanism.

This section describes the engagement program that has supported the development of the Yellowtail Project EIA, as well as planned engagement to support disclosure of the EIA.

4.7.1. Engagement Strategy and Planning

4.7.1.1. Context

In addition to the Yellowtail Project, EEPGL's operations in Guyana include the following ongoing activities:

- Engagement activities related to the planned onshore Gas to Energy Project have been underway in parallel to the Yellowtail Project. Scoping meetings for the Gas to Energy Project were held in July 2021 in communities in Regions 1 through 6.
- EEPGL has ongoing engagement with fishing communities regarding the offshore activities of previous development projects (Liza Phase 1, Liza Phase 2, and Payara), with the objective of answering questions and sharing information with fisherfolk about activities and impacts in the marine environment. These activities also relate to the participatory fish study contracted by EEPGL between 2019 and 2020, for which a second phase of study began in 2021.
- Socioeconomic baseline data and related studies (including ecosystem services) include information compiled between 2017 and 2019. Although the outcomes of these studies continue to be relevant, EEPGL and Environmental Resources Management (ERM) identified opportunities to update community-specific information through engagement in Regions 1 through 6, and to request updated data (where available) from government agencies and other stakeholders. This engagement has also provided an opportunity to understand changes related to the coronavirus disease 2019 (COVID-19) pandemic and other socioeconomic updates for the last 1 to 2 years.

The physical distancing requirements of COVID-19 have added a layer of complication for in-person engagement, although in-person meetings for the Yellowtail Project were well attended. However, flooding events in June 2021 increased hardship for many communities, and COVID-19 cases have been rising across Guyana (including Region 1) in recent months. EEPGL acknowledges these challenges and commits to supporting public health and the wellbeing of all stakeholders as it pursues its engagement objectives.

4.7.1.2. Stakeholder Engagement Plan

The Yellowtail Project EIA is occurring alongside other EEPGL development projects in Guyana, including the proposed Gas to Energy Project. Additionally, the stakeholder engagement process for the Yellowtail Project has benefited from the knowledge and understanding gained through EEPGL's past and ongoing engagement activities, including engagement related to EIAs for other offshore development projects conducted since 2016. EEPGL's Stakeholder Engagement Plan for Guyana Operations (the SEP) guides Project stakeholder engagement activities. The SEP describes the following:

- Stakeholders identified for engagement;
- A program of engagement and communications activities throughout the Project life cycle;
- Formal stakeholder feedback mechanisms, including a dedicated phone line and email address through which stakeholders can contact EEPGL to voice concerns, provide information, or ask questions about the Project and its activities; and
- Mechanisms through which EEPGL will monitor and report on external engagement and communications.

The SEP is a document that is updated periodically as the Project progresses to reflect new information, changing conditions, and additional stakeholders. The SEP is included as a part of this EIA in Volume III. Information attached to the SEP provides an account of the multiple years of engagement that have taken place by EEPGL and its consultants, including engagement with indigenous communities. Attachments also include examples of non-technical materials used to share information during engagement and templates used for engagements related to ecosystem services studies, participatory fishing studies, social infrastructure studies, and one-on-one meetings (including with indigenous communities).

4.7.1.3. Engagement Strategy

Supporting the SEP, EEPGL's stakeholder engagement strategy identifies mechanisms and tools to facilitate stakeholder communications and public information sharing. These tools are divided into two tiers that interact to facilitate informed engagement: (1) information sharing and (2) consultation.

Information Sharing

EEPGL provides information about the Project to stakeholders to support their understanding of what is proposed to occur. EEPGL may disseminate information through print and online publications and media releases, as well as presentations and open houses. The intent of these types of activities is to provide information to a broad audience or group of stakeholders as efficiently as possible.

To support stakeholder understanding of the technically complex EIA submittal, the Project engagement program has included a non-technical summary of the EIA, supported by visual aids to support a layperson's understanding of the proposed Yellowtail Project. EEPGL has also developed and distributed other materials (posters, brochures, handout materials, photo books)

to help explain the Project impacts and benefits in a deliberative way and with simple communication tools that are inclusive and tailored to different audiences, including indigenous and vulnerable populations. Examples of materials developed to support engagement to date are attached to the SEP in Volume III of this EIA.

Consultation

EEPGL seeks to support open dialogue and receive stakeholder feedback, opinions, concerns, and knowledge regarding the way the Project may interact with the natural and social environment. Through consultation, EEPGL's objective is to identify key stakeholder issues and concerns.

Consultation or dialogue activities involve a two-way flow or exchange of information between stakeholders and EEPGL or the Consultants. Consultation activities for the Yellowtail Project have included one-on-one and small-group meetings, public meetings including question and answer sessions, and feedback mechanisms such as a dedicated email address (guyanastaff@exxonmobil.com) and phone line (+592 231 2866). EEPGL also communicates regularly with its stakeholders through its Facebook page.[3] The intent of these activities is to allow for not only a two-way exchange of information, but also a means for EEPGL to gather information concerning topics that are important to its stakeholders. These activities also help ensure stakeholder comments and opinions are heard and legitimate concerns are addressed.

Throughout all engagement, EEPGL and the Consultants have taken advantage of different scopes of work (for the Yellowtail Project as well as the Liza Phase 1, Liza Phase 2, and Payara development projects) to identify and engage with vulnerable groups, including indigenous communities. EEPGL and the Consultants also take specific care during public engagements to understand the opinions of women, the elderly, and youth by ensuring all participants were provided with the opportunity to speak, if desired.

Specific to Indigenous Peoples, EEPGL respects the rights and cultures of Indigenous Peoples and commits to conducting meaningful consultations with them, incorporating traditional knowledge and use into its plans, and seeking mutually beneficial long-term relationships. EEPGL further recognizes that Free, Prior and Informed Consent is a process by which accurate, accessible, and timely information is shared in regard to proposed developments, with opportunities for constructive and two-way dialogue. EEPGL's stakeholder engagement program has included (and continues to include) indigenous communities and Toshaos in Regions 1 and 2. EEPGL has been responsive to the questions, concerns, and interests of indigenous stakeholders and continues to work with these communities to identify opportunities to support local benefits.

Continued Engagement

EEPGL has a program of ongoing stakeholder engagement and community outreach in Regions 1 through 6 and is regularly in touch with stakeholders to provide updates about projects, offshore activities, community investment initiatives, and other matters. Since 2017

[3] https://www.facebook.com/exxonmobilguyana/

and through the time of writing this EIA, EEPGL and its Consultants have held hundreds of stakeholder engagement events in the coastal Regions 1, 2, 3, 5, and 6, and more than 1,000 engagement events and individual stakeholder meetings in Region 4 related to the Liza Phase 1, Liza Phase 2, Payara, and Yellowtail development projects. Engagements have included key informant interviews, EIA public scoping consultation and disclosure meetings, coastal mapping efforts, fisherfolk engagement, oil spill response training, community outreach events (e.g., informational booths, school fairs, job fairs), and capacity-building efforts.

EEPGL and the Consultants document these activities in an engagement database to ensure follow-up of legitimate concerns. Documentation of stakeholder engagement activities, and related monitoring, evaluation and reporting is managed through EEPGL's environmental and social management system (ESMS). This system provides for the consistent and centralized documentation of records, integrated within EEPGL's management systems, and verifies that follow-up actions are assigned and completed.

Engagement planning efforts include targeted engagement and participatory opportunities to address high impact / high influence stakeholder groups. For example, recognizing the importance of fishing livelihoods and communities, EEPGL supports the Participatory Fishing Study (PFS), which began in 2019 and is ongoing. The PFS involves local fisherfolk (a high priority stakeholder group) in Regions 1 through 6, including representatives at landing sites along the coast, and on-board fishing vessels, to monitor changes in fish catch and fishing effort. Engagement that occurs through the PFS (and other engagement programs targeted at high impact / high priority stakeholders) is tracked through the ESMS, as for other engagements. Issues and concerns raised by these groups are tracked, responses are provided, and follow-up actions are verified through this centralized, integrated management system.

Engagement specific to the Yellowtail Project is discussed in Sections 4.7.2, Engagement to Date, to 4.7.4, Post-EIA Engagement.

4.7.1.4. Stakeholder Identification

In accordance with the SEP and as outlined in the Terms and Scope, ERM evaluated and prioritized a long list of potential Project stakeholders based on their anticipated interest in and influence on the Project. Stakeholders included those with perceived positive, negative, and neutral positions related to the Project. In total, more than 120 stakeholder groups were identified from the following categories:

- Government ministries, departments, and other agencies;
- Non-governmental organization (NGOs);
- Communities and Indigenous Peoples in Regions 1 through 6, including Regional Democratic Councils (RDCs), Neighborhood Democratic Councils (NDCs), and Toshaos;
- Fisherfolk;
- Businesses and industry groups;

- Chambers of commerce and economic development organizations;
- Other local groups including women, elders, disability advocates; and
- Academic institutions

Project stakeholders have been identified, and their interests considered, through a combination of desktop research and in-country assessment and engagement. The understanding of stakeholders and their potential interests and concerns related to the Project has directly informed the engagement program to date and plans for engagement through the EIA disclosure period.

4.7.1.5. COVID-19 Precautions

All engagement has been, and continues to be, conducted in accordance with applicable COVID-19 regulations and precautions including physical distancing, use of personal protective equipment (e.g., masks), limitations of gathering size, and compliance with vaccination requirements. As pandemic conditions and control measures frequently change, EEPGL will continue to work with relevant authorities including the National COVID-19 Task Force to determine and comply with the appropriate precautions at each stage of engagement.

4.7.2. Engagement to Date

EEPGL and its consultants have engaged with communities, government agencies, and other stakeholders since 2013 in relation to past development projects including Liza Phase 1, Liza Phase 2, and Payara offshore development projects. Specific to the Yellowtail Project, engagement to date has included:

- EIA scoping meetings to inform the Terms and Scope of the EIA;
- Key informant interviews, meetings, and discussions to inform the Consultants' understanding of existing conditions and stakeholders' perceptions and concerns as part of EIA development; and
- EIA disclosure meetings to share the findings of the EIA and solicit feedback from stakeholders.

4.7.2.1. Prior Development Projects

EEPGL and its consultants have conducted extensive engagement efforts in support of the Liza Phase 1, Liza Phase 2, and Payara development projects. These engagements have provided a range of opportunities for community members, special interest groups, fisherfolk, businesses, conservation groups, Indigenous Peoples, and other stakeholders to learn about the offshore development projects, discuss concerns and potential impacts, and provide input into the EIA.

Table 4.7-1 summarizes the highlights of these activities for the most recent offshore development project, the Payara Project in 2019.

Table 4.7-1: Summary of Key Informant Interviews and Other Engagements for Payara Development Project, 2019

Engagement Summary/Topics	Participating Stakeholders
Community and Regional Engagement	
The Consultants and the Chelonian Research Institute, in collaboration with the Protected Areas Commission, conducted a Turtle Telemetry Capacity Building Workshop. At this workshop, the methodology, techniques, and findings of the Liza Phase 1 Development Project Turtle Telemetry Program (conducted in 2018) were presented to participants.	Protected Areas Commission, EPA, Fisheries Department, Guyana Marine Conservation Society, and Guyana Wildlife Conservation and Management Commission
The Consultants held interviews with 82 fisherfolk to obtain biological and socioeconomic data from these fisherfolk regarding artisanal and commercial fishing activities.	Fisherfolk at 16 fisheries landing sites in Regions 1 to 6
The Consultants engaged with hotels and realtors in the Georgetown area to understand available facilities, existing capacity rates, and demand forecasting, as well as real estate trends in Region 4 and other regions. Discussions also sought to understand current and potential influence from the increased activity in the oil and gas sector.	Hotels (14) and realtors (8) based in Region 4
Validation of the Ecosystem Services study results involved engagement with a total of 574 stakeholders in Regions 1 to 6. Stakeholders stated their concerns and expressed an interest in learning more about oil and gas in general, and asked about potential benefits such as opportunities for employment and training.	A total of 61 unique engagements with coastal NDCs, RDCs, town councils, and VCs in Regions 1 to 6
Validation of the Ecosystem Services study results involved in-person engagement with 13 coastal Amerindian communities, including indigenous communities in and around the Shell Beach Protected Area. Meetings also provided information about EEPGL's operations. A National Toshaos Council representative attended all meetings to ensure that engagements were fair and impartial and that the concerns of the indigenous communities were accurately expressed.	Indigenous communities (13) in Region 1
Engagement with Government Agencies, Commissions, Professional or Business Associations, NGOs, and Elected Officials and Regional Administrators	
• Centre for Local Business Development (CLBD) Supplier Registration Portal • Training programs offered on behalf of EEPGL by the CLBD • Views on how the CLBD contributes to local content • How the oil and gas sector is likely to contribute to national development in Guyana	CLBD
• Concerns on how the oil and gas sector may influence cultural heritage sites in Georgetown • Plans for reconsidering the current system for historical preservation of these sites • Shared data on cultural heritage sites and archaeological sites in Guyana	National Trust of Guyana
• Views on how the oil and gas sector may impact tourism in Guyana • Plans for development of tourism initiatives in Regions 1 through 6	Ministry of Tourism, Industry and Commerce (formerly Ministry of Business)

Engagement Summary/Topics	Participating Stakeholders
• Plans for enhancing the management of Guyana's fisheries sector and further development of the sector, including deep-sea fishing • Challenges facing the fishing industry • Concerns for the fishing sector as it pertains to oil and gas.	Ministry of Agriculture, Fisheries Department
• Feedback on mangrove coverage in the coastal sensitivity maps prepared as part of the Liza Phase 1 Development Project Ecosystem Services Study • Information on a mangrove-mapping project that is being implemented in collaboration with Conservation International • Plans for additional mangrove restoration activities, including in Region 1	National Agricultural Research and Extension Institute
• Plans for the housing and water sectors • Question of how oil and gas may influence the socioeconomic conditions of Regions 7 through 10 • Suggestion that the EIA should include a study on commercial sex workers in relation to the oil and gas sector	Ministry of Local Government and Regional Development (formerly Ministry of Communities)
• Request that the EIA assess critical habitats that need special treatment under International Finance Corporation Performance Standard 6 • Cumulative research efforts, in particular for biological studies • Goal of the EIA in support of environmental management • Plans for waste disposal including use of the Haags Bosch Landfill • Need for a non-technical Executive Summary to support engagement • Concerns on traffic congestion and safety in the vicinity of the Guyana Shorebase Inc. facility	Conservation International
• Suggestion for one cumulative EIA instead of multiple EIAs for offshore development projects • Plans for developing courses to prepare students for employment in oil and gas, welcoming partnerships with EEPGL and the Consultants to share knowledge and experiences with students	University of Guyana
• Changing demands for land in Region 4, particularly in Georgetown, as a result of growing oil-and-gas sector • Plans for enhancing the system for integrated land use planning in Guyana	Guyana Lands and Surveys Commission
• Need to ensure the welfare, health, and safety of Guyanese workers • Shared information on the process to develop occupational health and safety regulations for the oil and gas sector	Ministry of Human Services and Social Security (formerly Ministry of Social Protection)
• Shared views on how the oil and gas sector may impact the agricultural sector and information on projects to develop the agricultural sector, including value-added initiatives • Shared statistics for the agricultural sector	Ministry of Agriculture
• Request that the EIA consider the volumes and disposal methods for general solid waste that will be generated offshore activities • Methods for managing increased vessel traffic in Georgetown Harbour • Probabilities of significant oil spills occurring in Guyana • Security for the FPSO vessel against foreign military vessels	Guyana Geology and Mines Commission
• Shared plans for including oil and gas in the national accounts and provided updates on several surveys that are being planned and implemented by the bureau	Bureau of Statistics
• Shared commitment to actively engage in the stakeholder engagement process for the project as part of the regulatory process led by the EPA	World Wildlife Fund

Engagement Summary/Topics	Participating Stakeholders
• Shared views that the National Toshaos Council and Guyana Marine Conservation Society should be included in engagement in Region 1 • Enquired about the methods of biological and socioeconomic baseline data collection in indigenous communities • Requested that all stakeholders be engaged in a single session going forward (instead of one-on-one engagements)	Protected Areas Commission

CLBD = Centre for Local Business Development; FPSO = Floating Production, Storage, and Offloading; VC = Village Council

4.7.2.2. Fisherfolk Engagement

Engagement with fishing cooperatives in all six regions, covering 16 landing sites, occurred on at least a monthly basis as part of an EEPGL-commissioned Participatory Fish Study between January 2019 and March 2020. The study resumed in March 2021 with the goal of re-engaging with fisherfolk to collect data and build on the knowledge base established by the original study and examining emerging trends related to artisanal and industrial fisheries in Guyana. Outcomes of the participatory fishing engagement are reported quarterly. At the time of writing, the most recent report addresses findings from April to June 2021; these findings have been considered in the development of this EIA.

Details of the Participatory Fishing Study can be found in Appendix D, Participatory Fishing Study Final Report January 2019–March 2020, and *Participatory Fish Study Quarterly Report April–June 2021* (EMC 2021).

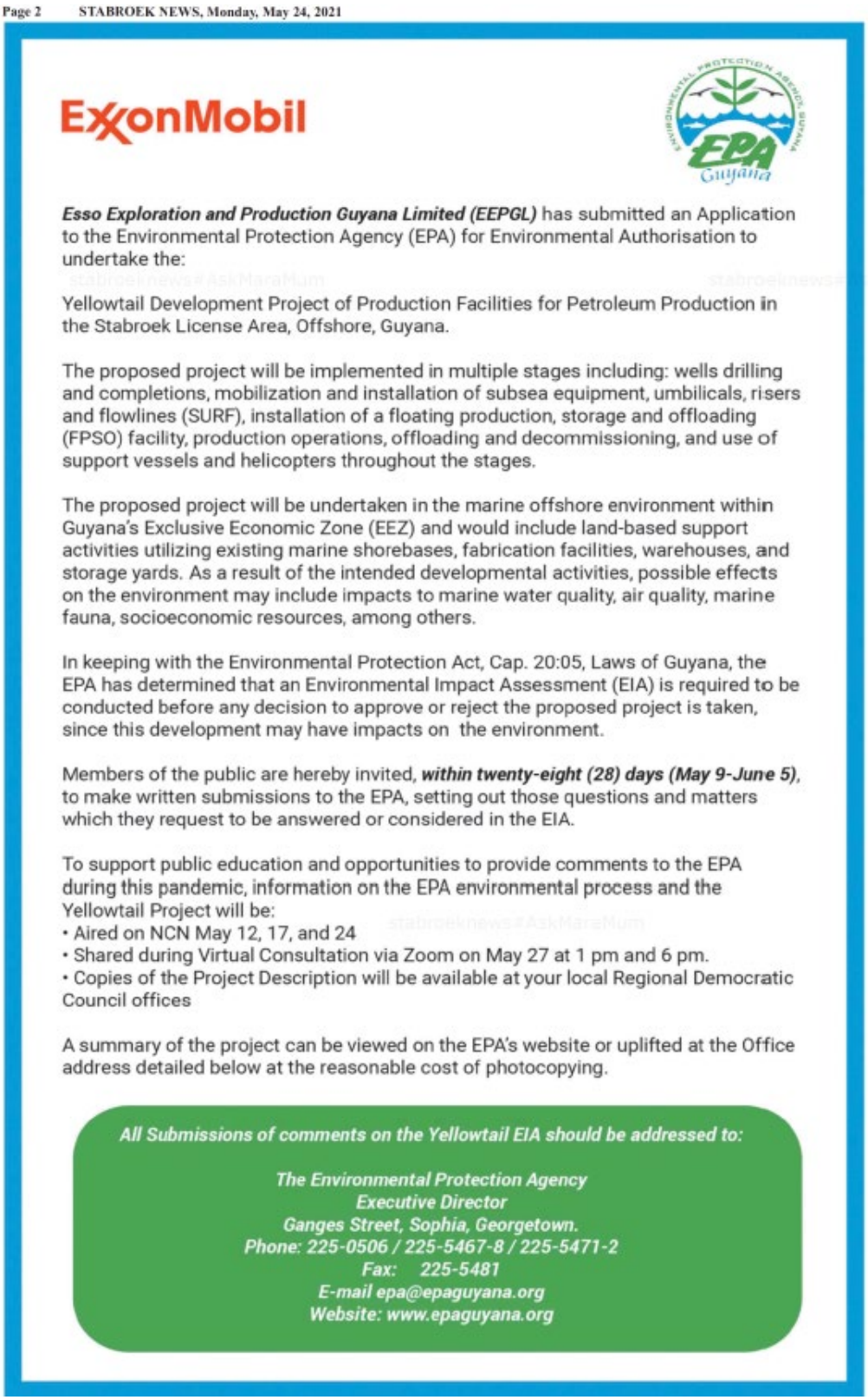
4.7.2.3. EIA Scoping

Information Distribution

After EEPGL submitted the application for the Project to the EPA, a public notice was published in the Stabroek News on 9 May 2021 and posted on the EPA's website on the same day (Figures 4.7-1 and 4.7-2, respectively). The public notice marked the start of the 28-day public comment period for the scoping stage and provided information about where and how the public could access information about the EPA process and the Yellowtail Project. EEPGL also posted advertisements announcing upcoming meetings (Figure 4.7-3).

EEPGL distributed meeting notices and Project summary flyers for the public scoping consultation meetings to communities throughout Guyana. Materials were couriered directly to the RDCs of Regions 1 through 10, as well as to 89 NDCs, Community Councils, and Village Councils (VCs) in these regions (including 86 NDCs, Community Councils, and VCs in Regions 1 through 6).

In addition, video summaries of the EPA process and Project description were aired on television (NCN network) on 12, 17, and 24 May 2021. These videos were also aired in the public scoping meetings.



Page 2 STABROEK NEWS, Monday, May 24, 2021

ExxonMobil

Esso Exploration and Production Guyana Limited (EEPGL) has submitted an Application to the Environmental Protection Agency (EPA) for Environmental Authorisation to undertake the:

Yellowtail Development Project of Production Facilities for Petroleum Production in the Stabroek License Area, Offshore, Guyana.

The proposed project will be implemented in multiple stages including: wells drilling and completions, mobilization and installation of subsea equipment, umbilicals, risers and flowlines (SURF), installation of a floating production, storage and offloading (FPSO) facility, production operations, offloading and decommissioning, and use of support vessels and helicopters throughout the stages.

The proposed project will be undertaken in the marine offshore environment within Guyana's Exclusive Economic Zone (EEZ) and would include land-based support activities utilizing existing marine shorebases, fabrication facilities, warehouses, and storage yards. As a result of the intended developmental activities, possible effects on the environment may include impacts to marine water quality, air quality, marine fauna, socioeconomic resources, among others.

In keeping with the Environmental Protection Act, Cap. 20:05, Laws of Guyana, the EPA has determined that an Environmental Impact Assessment (EIA) is required to be conducted before any decision to approve or reject the proposed project is taken, since this development may have impacts on the environment.

Members of the public are hereby invited, ***within twenty-eight (28) days (May 9-June 5)***, to make written submissions to the EPA, setting out those questions and matters which they request to be answered or considered in the EIA.

To support public education and opportunities to provide comments to the EPA during this pandemic, information on the EPA environmental process and the Yellowtail Project will be:
- Aired on NCN May 12, 17, and 24
- Shared during Virtual Consultation via Zoom on May 27 at 1 pm and 6 pm.
- Copies of the Project Description will be available at your local Regional Democratic Council offices

A summary of the project can be viewed on the EPA's website or uplifted at the Office address detailed below at the reasonable cost of photocopying.

All Submissions of comments on the Yellowtail EIA should be addressed to:

The Environmental Protection Agency
Executive Director
Ganges Street, Sophia, Georgetown.
Phone: 225-0506 / 225-5467-8 / 225-5471-2
Fax: 225-5481
E-mail epa@epaguyana.org
Website: www.epaguyana.org

Figure 4.7-1: Notice to the Public Initiating 28-Day Public Comment Period—Newspaper Notice

Environmental Protection Agency

Notice to the Public

May 09, 2021 - Esso Exploration and Production Guyana Limited (EEPGL) has submitted an Application to the Environmental Protection Agency (EPA) for Environmental Authorisation to undertake the following project:

Yellowtail Development Project of Production Facilities for Petroleum Production within the Stabroek License Area, Offshore, Guyana.

The proposed project will be implemented in multiple stages including: wells drilling and completions, mobilization and installation of subsea equipment, umbilicals, risers and flowlines (SURF), installation of a floating production, storage and offloading (FPSO) facility, production operations, offloading of crude and decommissioning, and use of support vessels and helicopters throughout the stages. The proposed project will be undertaken in the marine offshore environment within Guyana's Exclusive Economic Zone (EEZ) and would also utilise land-based support activities such as marine shorebases, fabrication facilities, warehouses, and storage yards. As a result of the intended developmental activities, possible effects on the environment may include impacts to marine water quality, air quality, marine fauna, socio-economic resources, among others.

In keeping with the Environmental Protection Act, Cap. 20:05, Laws of Guyana, the EPA has determined that an Environmental Impact Assessment (EIA) is required to be conducted before any decision to approve or reject the proposed project is taken, since this development may significantly impact the environment.

Members of the public are hereby invited, **within twenty-eight (28) days** of this Notice, to make written submissions to the Agency, setting out those questions and matters which they require to be answered or considered in the EIA.

A summary of the project can be viewed on the EPA's website or uplifted at the office address detailed below at the reasonable cost of photocopying.

Submissions should be addressed to:

The Environmental Protection Agency
Executive Director
Ganges Street, Sophia, Georgetown.
Phone: 225-0506 / 225-5467-8 / 225-5471-2
Fax: 225-5481
E-mail epa@epaguyana.org
Website: www.epaguyana.org

Figure 4.7-2: Notice to the Public Initiating 28-Day Public Comment Period—EPA Website

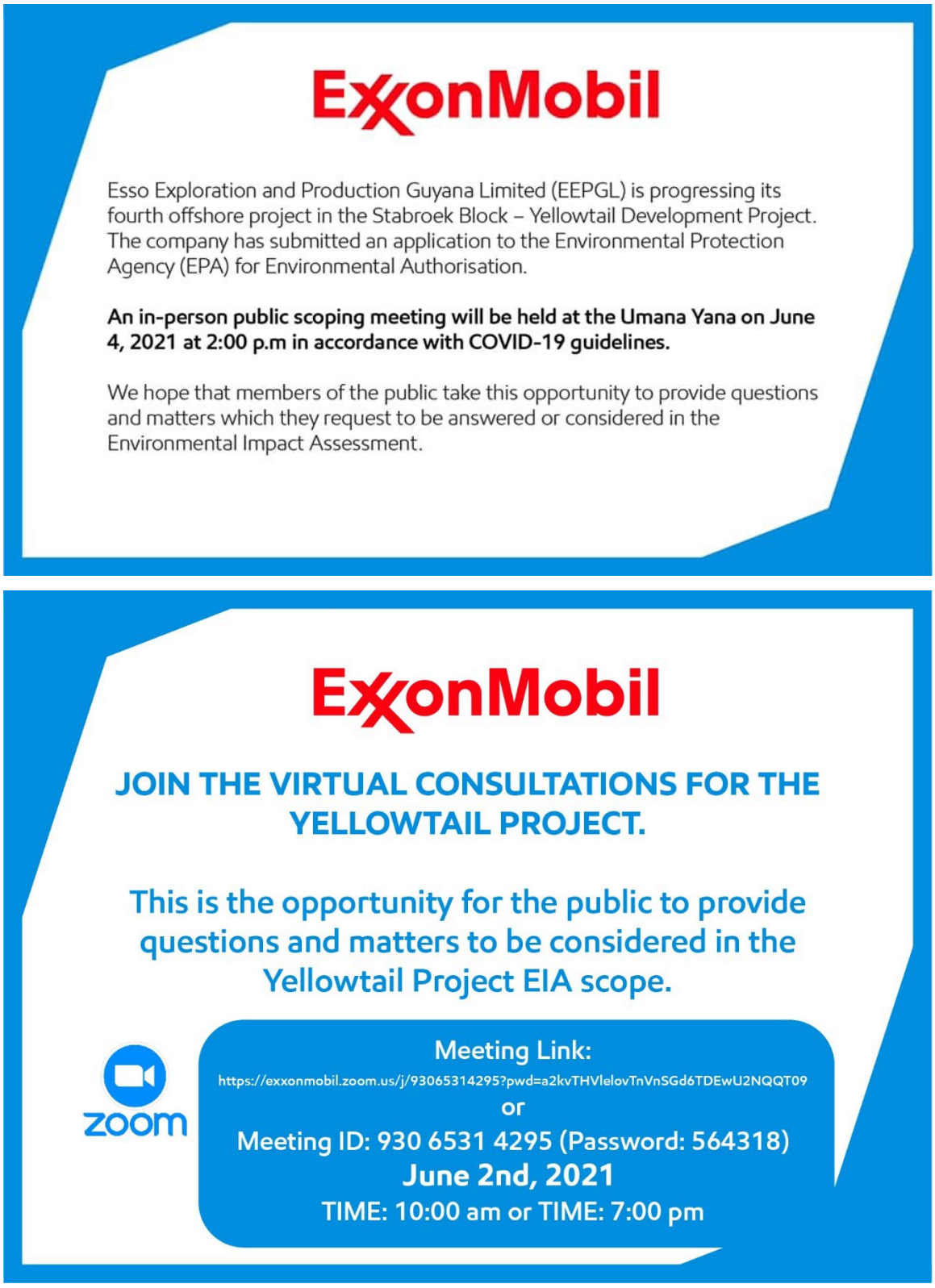


Figure 4.7-3: Examples of Public Notices Advertising Public Consultation Meetings

Scoping Meetings

Scoping meetings for the Project were hosted by the EPA and EEPGL in May and June 2021. A mix of virtual and in-person meetings was held, as summarized in Table 4.7-2. All meetings included an overview of the environmental review process by the EPA, an overview of the proposed Yellowtail Project from EEPGL, and an opportunity for stakeholders, special interest groups, and members of the public to identify issues and concerns to be considered in the development of the Terms and Scope for the Yellowtail Project EIA. EEPGL and the Consultants also took specific care during public engagements to understand the opinions of women, the elderly, and youth by ensuring all participants were provided with the opportunity to speak, if they so desired.

Table 4.7-2. Yellowtail Development Project Scoping Meetings, 2021

Date	Location	Number of Participants
May 27	Virtual (Zoom meeting)—afternoon session	42 participants
	Virtual (Zoom meeting)—evening session	Not available
May 28	No. 66 Village (Region 6)	35 participants
May 31	Mabaruma (Region 1)	46 participants
June 2	Virtual (Zoom meeting)—morning session	25 participants
	Virtual (Zoom meeting)—evening session	36 participants
June 4	Georgetown (Region 4)	15 participants

Issues and concerns raised during the scoping stage have informed the development of this EIA, including the understanding of the baseline socioeconomic and biophysical environment, potential impacts, and the development of mitigation and management measures. In addition to comments raised during scoping meetings, members of the public and other stakeholders could also provide comments directly to the EPA. Consolidated comments from the scoping stage are summarized in Section 4.7.3, Stakeholder Comments and Considerations.

4.7.2.4. EIA Development

EEPGL and its consultants engaged with various stakeholders (Table 4.7-3) to request new or updated information in support of the Yellowtail Project EIA. To avoid stakeholder fatigue, the engagement plan for the Yellowtail Project prioritized key stakeholders based on the Project's specific needs and data gaps. Engagement during the EIA development stage has included emails, phone calls, and key informant interviews with a variety of stakeholders, including NDCs, RDCs, and Toshaos in Regions 1 through 6. A mix of in-person meetings, virtual meetings, emails and phone calls was used based on the objectives of engagement and stakeholder preferences.

Table 4.7-3. Engagement Objectives: EIA Development

Stakeholder Group or Category	Description of EIA Development Engagement Objectives
EPA	• Consult with the EPA to ensure alignment on EIA content and methods.
Government of Guyana: Ministries and Departments	• Engage with Bureau of Statistics, Ministry of Agriculture, Ministry of Health, National Trust, and other relevant government offices to request updated socioeconomic statistics and validate information collected from local communities.
NGOs	• Engage with NGOs and other agencies to understand concerns related to the Project, in addition to those identified during the Yellowtail scoping period.
Fisherfolk	• Align with EEPGL's ongoing fisherfolk engagement program, including the Participatory Fishing Study, to provide Yellowtail updates and gather EIA inputs in Regions 1 through 6. • Coordinate and align engagement for the Project with other ongoing engagement to avoid stakeholder fatigue.
All	• Align with engagement/data validation for the Gas to Energy Project (where possible) to reduce stakeholder fatigue.
Communities in Regions 1 through 6	• Strategically update community-level baseline information to inform the Project EIA, with a focus on socioeconomic conditions and ecosystem services data, including (but not limited to) updated community population estimates and information regarding the impacts of the COVID-19 pandemic and flooding in recent months.

Overall, the Consultants connected with more than 50 stakeholders—including representatives of NDCs and Toshaos—to request updated information and/or conduct interviews in August and September 2021. Information received during this period has been incorporated into relevant sections of the EIA, including Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources, and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources. Engagements have included phone calls, virtual meetings, and face-to-face meetings with other stakeholders, depending on stakeholder preferences. A summary of comments received and information provided during this engagement is provided in Section 4.7.3.2, EIA Development. Relevant meeting and interview notes are included in Appendix W, Meeting Records—EIA Development.

4.7.2.5. EIA Disclosure and Review

Following submission of the EIA to the EPA on 15 October 2021, ERM facilitated engagement to share the results with and solicit feedback from the public and other stakeholders. Similar to the scoping stage, this included a combination of information distribution and participatory meetings intended to provide stakeholders with an opportunity to ask questions and provide comments on the EIA.

Information Distribution

Notification of the EIA submission and dissemination of information about the EIA and its findings included:

- Public notice of availability announcing the EIA and where the public can access further information, published in local newspapers (Figure 4.7-4) and on EEPGL's website / social media (Figure 4.7-5);
- Use of traditional media and social media to share information about the Project and EIA; and
- Distribution of a non-technical summary of the EIA (Figure 4.7-6), in printed and digital formats.

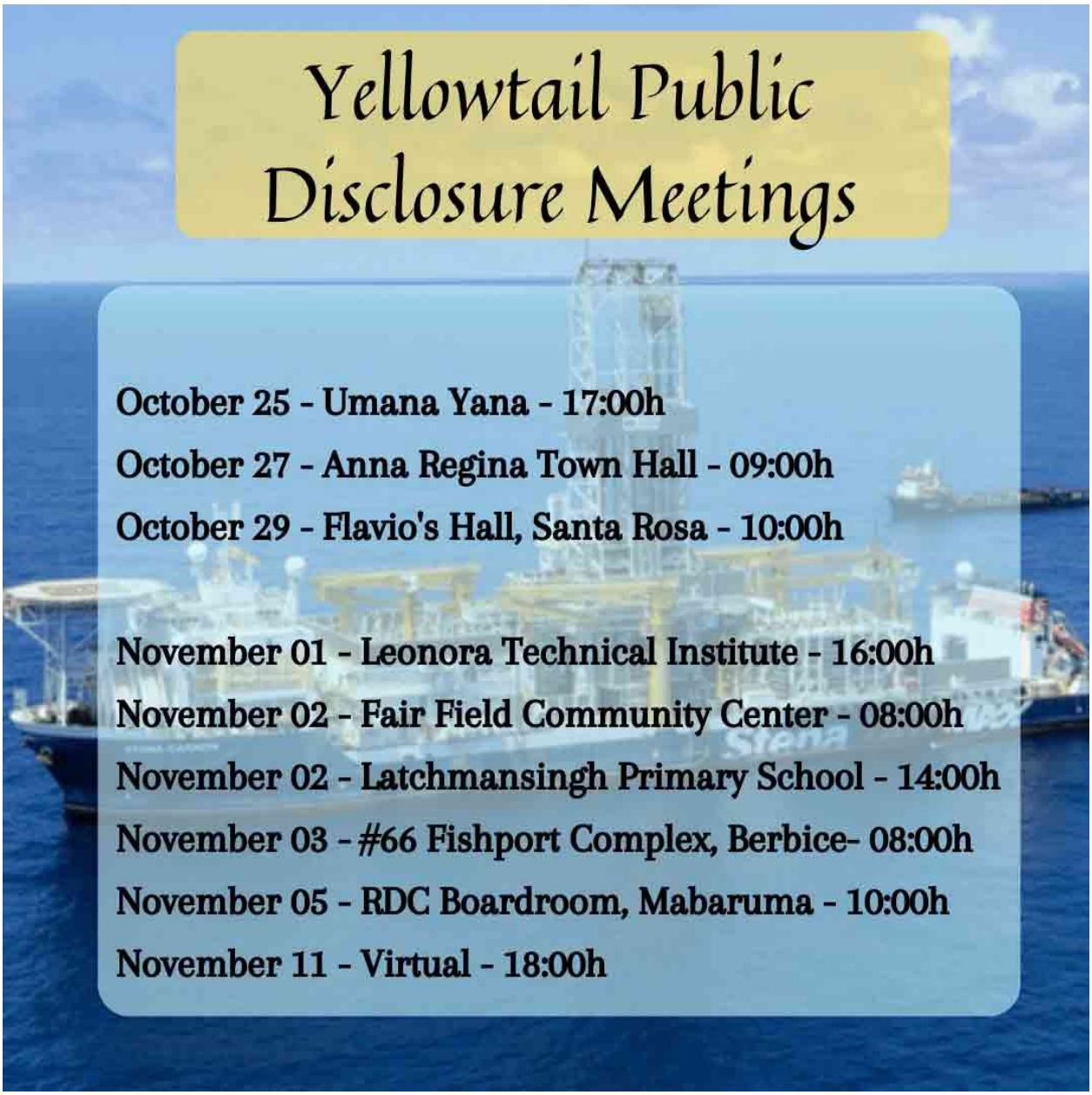
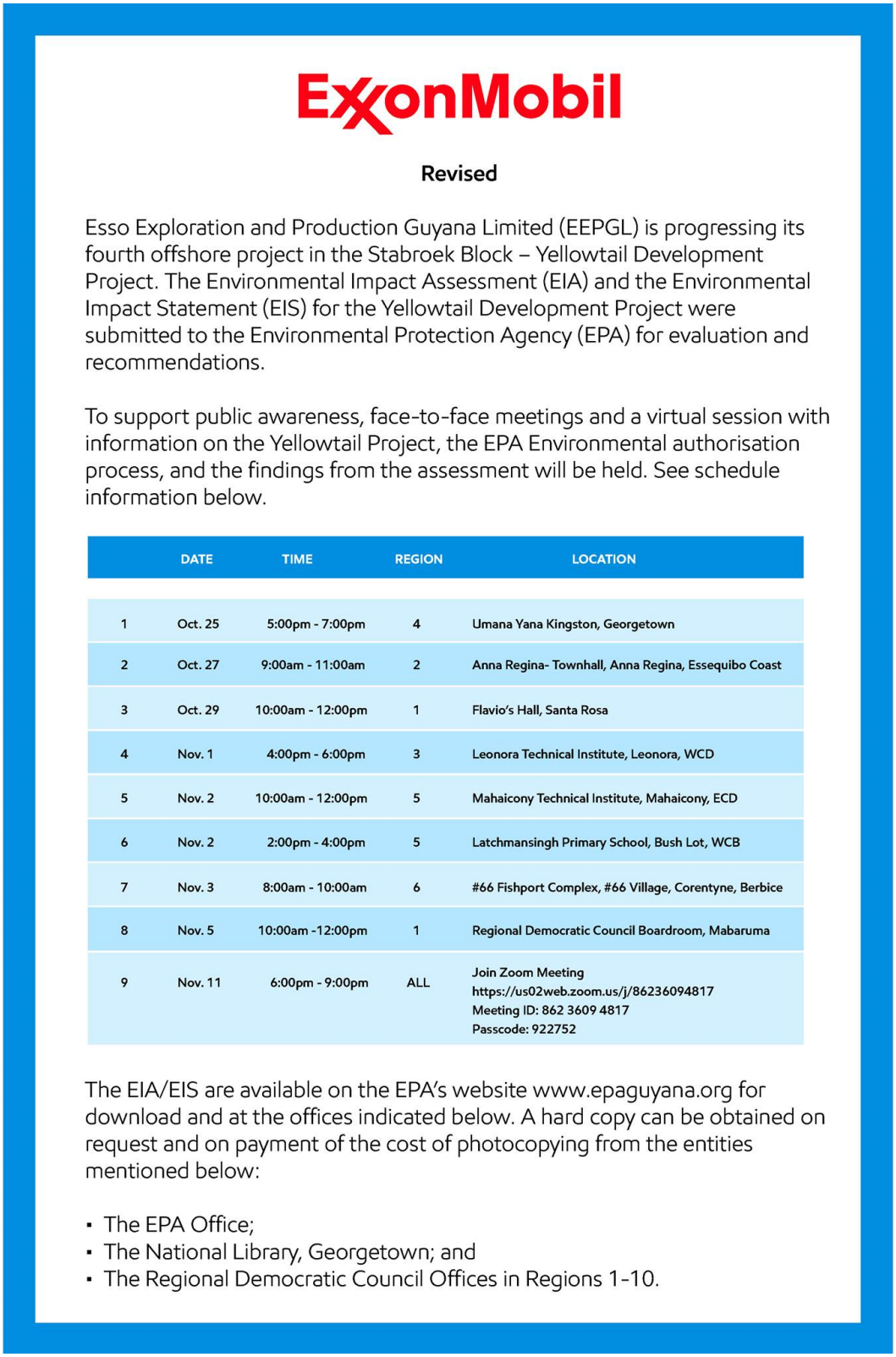


Figure 4.7-4: EIA Disclosure Meeting Announcement Published in Stabroek News, 10 November 2021



ExxonMobil

Revised

Esso Exploration and Production Guyana Limited (EEPGL) is progressing its fourth offshore project in the Stabroek Block – Yellowtail Development Project. The Environmental Impact Assessment (EIA) and the Environmental Impact Statement (EIS) for the Yellowtail Development Project were submitted to the Environmental Protection Agency (EPA) for evaluation and recommendations.

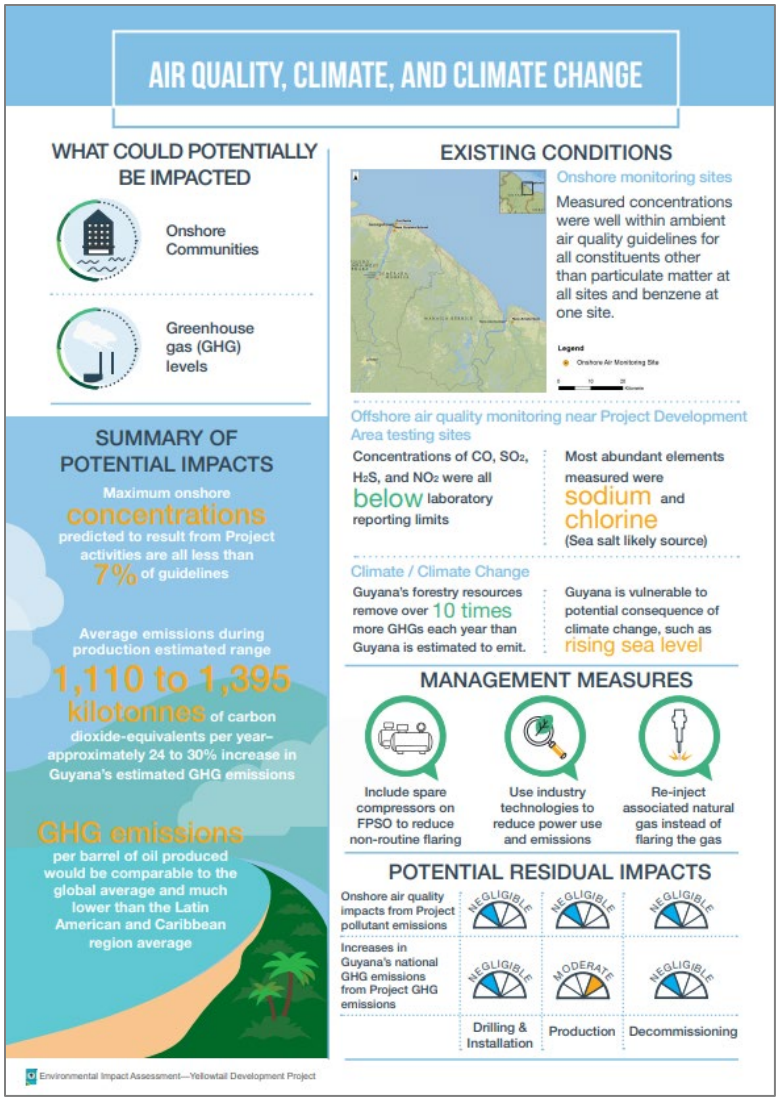
To support public awareness, face-to-face meetings and a virtual session with information on the Yellowtail Project, the EPA Environmental authorisation process, and the findings from the assessment will be held. See schedule information below.

	DATE	TIME	REGION	LOCATION
1	Oct. 25	5:00pm - 7:00pm	4	Umana Yana Kingston, Georgetown
2	Oct. 27	9:00am - 11:00am	2	Anna Regina- Townhall, Anna Regina, Essequibo Coast
3	Oct. 29	10:00am - 12:00pm	1	Flavio's Hall, Santa Rosa
4	Nov. 1	4:00pm - 6:00pm	3	Leonora Technical Institute, Leonora, WCD
5	Nov. 2	10:00am - 12:00pm	5	Mahaicony Technical Institute, Mahaicony, ECD
6	Nov. 2	2:00pm - 4:00pm	5	Latchmansingh Primary School, Bush Lot, WCB
7	Nov. 3	8:00am - 10:00am	6	#66 Fishport Complex, #66 Village, Corentyne, Berbice
8	Nov. 5	10:00am -12:00pm	1	Regional Democratic Council Boardroom, Mabaruma
9	Nov. 11	6:00pm - 9:00pm	ALL	Join Zoom Meeting https://us02web.zoom.us/j/86236094817 Meeting ID: 862 3609 4817 Passcode: 922752

The EIA/EIS are available on the EPA's website www.epaguyana.org for download and at the offices indicated below. A hard copy can be obtained on request and on payment of the cost of photocopying from the entities mentioned below:

- The EPA Office;
- The National Library, Georgetown; and
- The Regional Democratic Council Offices in Regions 1-10.

Figure 4.7-5: EIA Disclosure Meeting Announcement on EEPGL Facebook Page



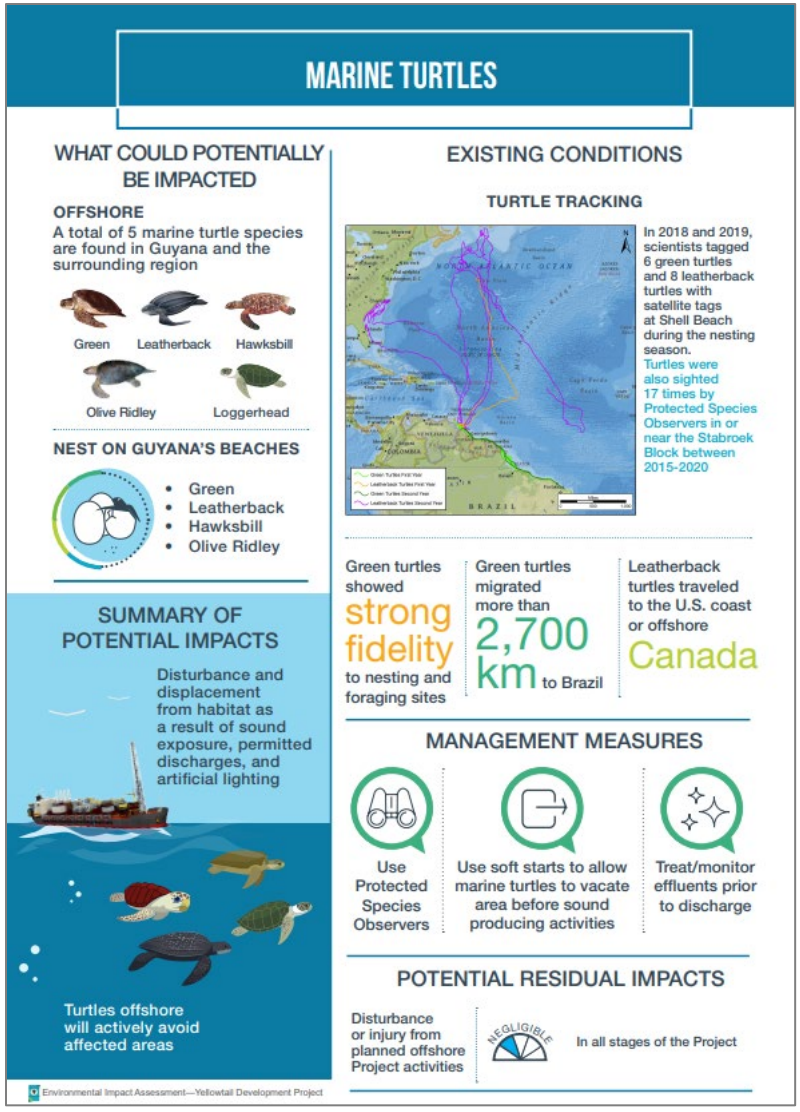


Figure 4.7-6: Excerpt of Yellowtail Project EIA Non-Technical Summary

Disclosure Meetings

After submittal of the EIA, and in collaboration with the EPA, ERM hosted a series of nine informational disclosure meetings for members of the public and community leaders, including at least one meeting in each of the six coastal regions. Meetings occurred between 25 October and 11 November 2021. These meetings provided the opportunity for stakeholders to learn about details of the EIA findings (including the potential environmental and socioeconomic effects of the Project) from the Consultants, and allow the public, community leaders, and government agencies to provide feedback on key issues addressed as part of the EIA.

At the public disclosure meetings, the Consultants' presented a summary of EIA findings (Figure 4.7-7) with a presentation designed and delivered for a non-technical, layperson audience. To further communicate information about the EIA, the Consultants displayed posters describing key findings of the impact assessment and supporting studies (Figure 4.7-8). During the meetings, participants were able to ask questions directly to the Consultants (as well as to the EPA and EEPGL, also in attendance). Responses were provided in the meetings, and comments and responses were also recorded as part of the public comment period (below).

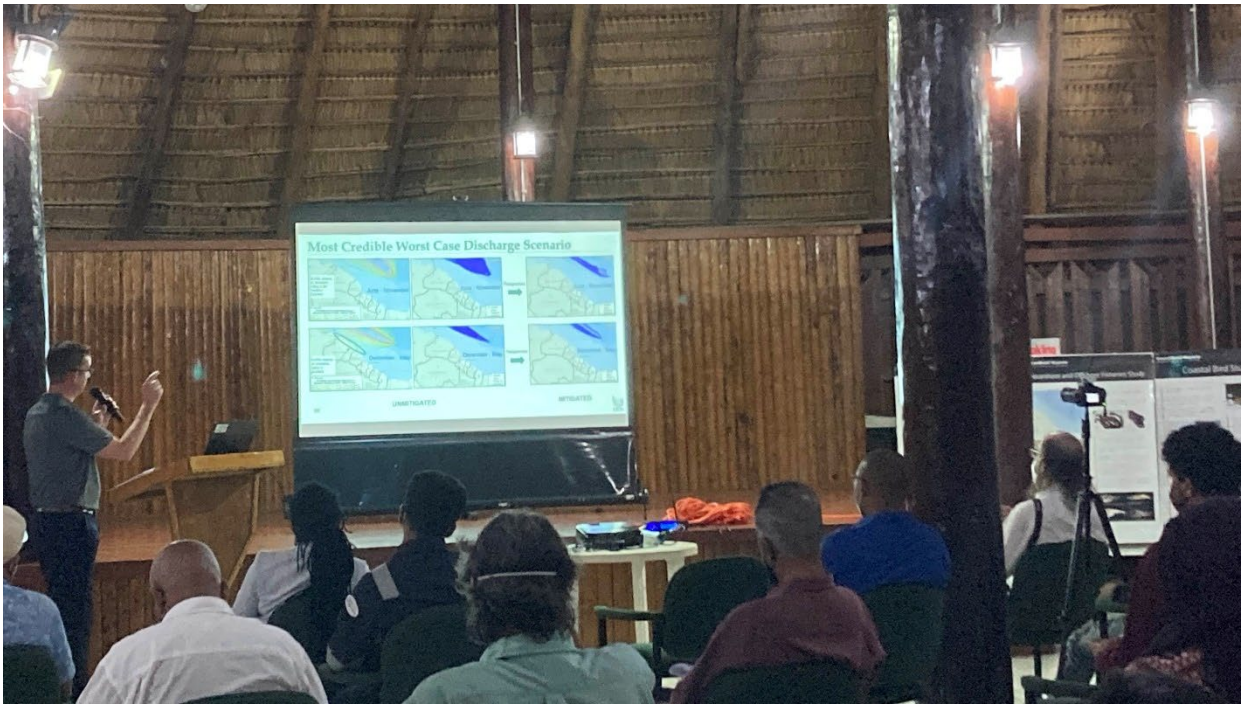
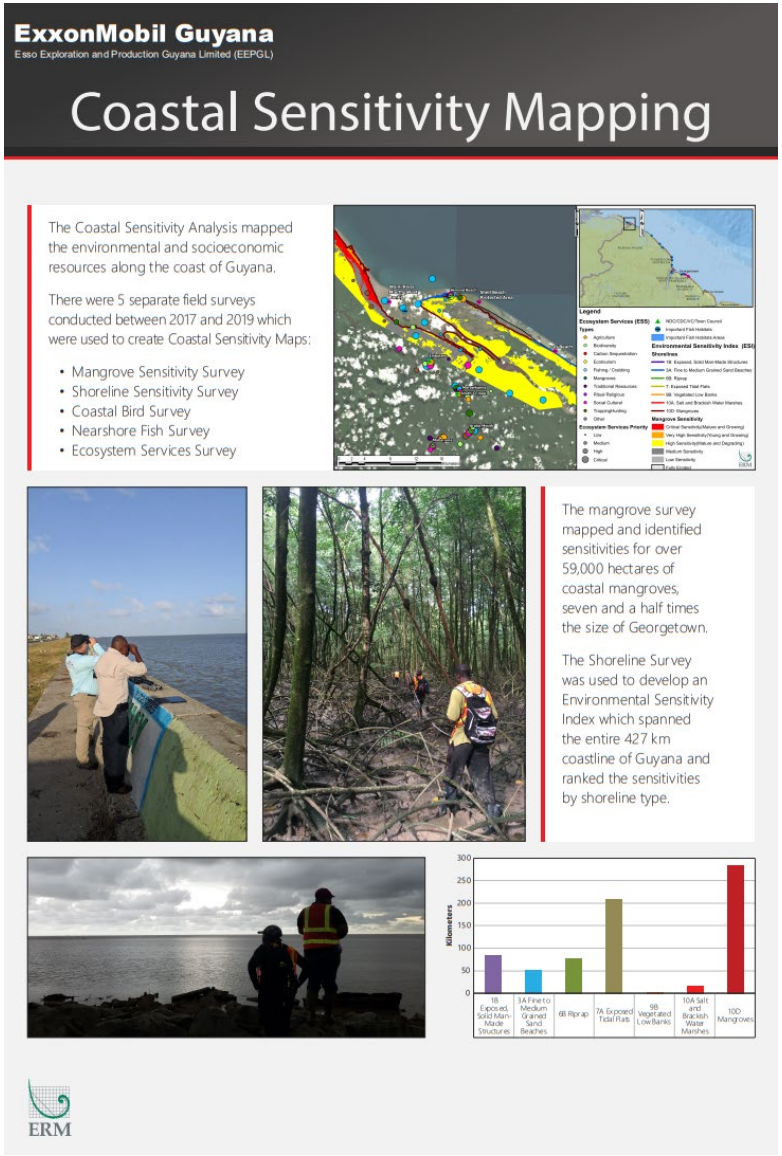


Figure 4.7-7: Presentation by the Consultants (ERM) at EIA Public Disclosure Meetings



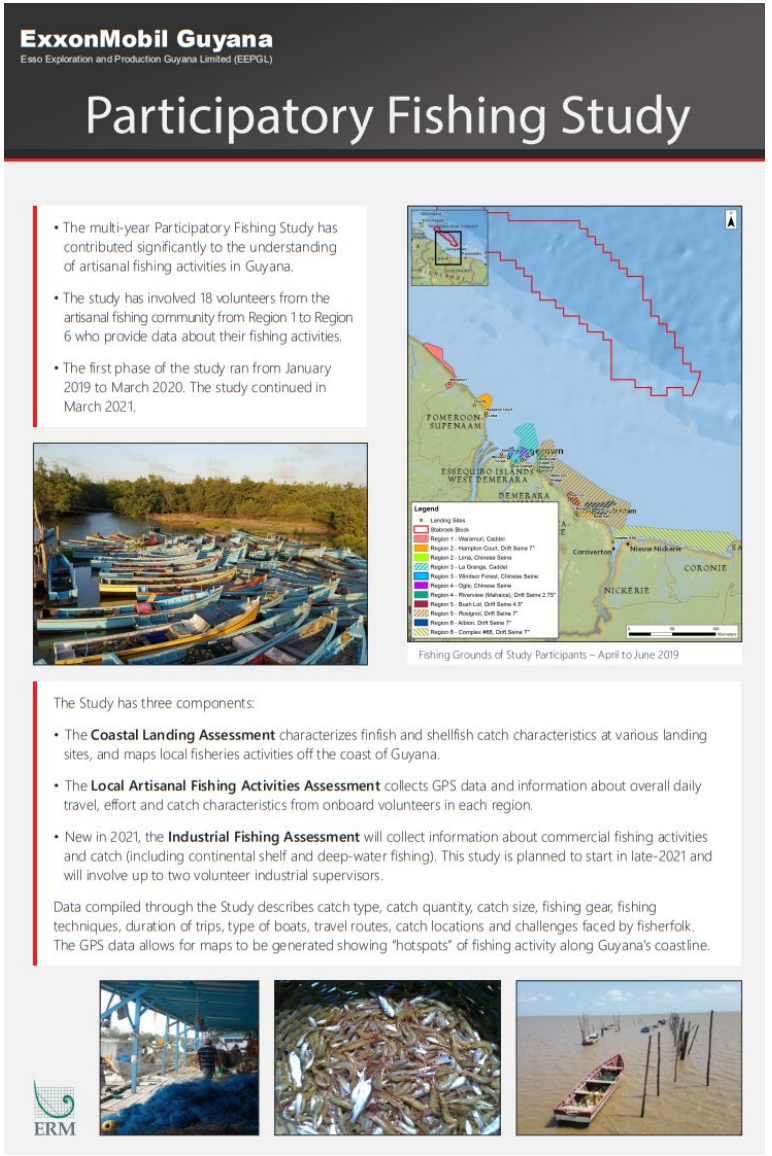


Figure 4.7-8: Informational Posters at EIA Public Disclosure Meetings

Public Comment Period

In accordance with the Environmental Protection Act, members of the public and interested organizations could submit comments on the EIA for a period of 60 days between 15 October and 15 December 2021. The EIA disclosure meetings (above) also occurred during this period, and comments and questions provided at the disclosure meetings were documented and included in the public record. Stakeholder comments and considerations are discussed further in Section 4.7.3.3, EIA Disclosure and Review.

4.7.3. Stakeholder Comments and Considerations

4.7.3.1. EIA Scoping

Scoping Consultation Comments

The Project scoping meetings (Section 4.7.2.3, EIA Scoping) served to inform stakeholders about the Project and allow stakeholders the opportunity to provide feedback. Stakeholders were also informed that comments could be submitted directly to the EPA. Eighty-three individual comments were recorded from attendees of the meetings. All comments, including those received verbally and in writing, have been reviewed and considered by the EPA in developing the Terms and Scope for this EIA and by EEPGL and the Consultants in the development of the EIA. Comments were received from a range of stakeholders including public, government agency, and NGO stakeholders over the course of the scoping phase.

Relevant comments received during the scoping process were formally documented by the EPA and are summarized in Table 4.7-4, along with an explanation of how the comment was addressed, as applicable, within the EIA. For some comments, the EPA provided a response during the meeting, and the table summarizes the EPA's response. Table 4.7-4 does not list every individual comment received; rather, comments addressing a similar issue are grouped, and the generalized comment is presented in the table (in some cases, a comment in the table represents a single individual comment). The generalized comments are organized by theme (e.g., Project Description, Oil Spill Response, etc.). Comments and questions that are not relevant to the Project EIA scoping process (e.g., employment opportunities, regulator actions) are not included.

Table 4.7-4: Thematic Summary of Comments Received from Public Scoping Consultation Meetings

Comments (Consolidated)	Consideration in the EIA
Climate Change	
How much is Guyana contributing to Global Warming with all oil and gas projects (1)	Section 6.1, Air Quality, Climate, and Climate Change, provides estimated GHG emissions from the Project and compares them to national, regional, and global GHG emissions. Chapter 10, Cumulative Impact Assessment, provides estimated GHG emissions for the combined EEPGL activities anticipated to occur during the Yellowtail Project life.
What would be the extent of the Project's contribution to climate change? What would be the amount of carbon released in terms of tons? (E)	
We are concerned about climate change (6)	
Will the proponent consider offsetting? We must agree there will be negative impacts with this type of development and we cannot run away from such as associated emissions and GHG. But at the same time Guyana as a country has a profile of historically good environmental stewardship. Will there be consideration not just of punitive measures but other measures that were instituted by the proponent to consider or support these types of offsets as a good practice, and not necessarily only as a result of a consequence of production? (E, V)	While offsetting relates to national policy issues that are beyond the scope of the Yellowtail EIA, Section 6.1, Air Quality, Climate, and Climate Change, addresses potential Project impacts on GHG emissions and describes the embedded controls and mitigation measures put in place by EEPGL to reduce GHG emissions from the Project.
Flaring	
Concerned about flaring Issues – fisherfolk claim that flaring is causing climate change and they are concerned about it (6)	Chapter 2, Description of the Project, discusses the Project description, including how flaring of associated gas is not planned as part of normal operations and temporary, non-routine flaring will occur during start-up and shutdown, equipment maintenance, process upsets, and emergency pressure-relieving scenarios. Chapter 2, Description of the Project, describes the measures incorporated into the Project design (e.g., equipment sparing) to reduce the frequency and duration of non-routine flaring events. Section 6.1, Air Quality, Climate, and Climate Change, discusses potential impacts on air quality, climate, and climate change, inclusive of a description of flaring controls. EEPGL will develop a flaring minimization plan for the Yellowtail Development Project.
Fisherfolk will not accept flaring (6)	
How does EEPGL plan to comply with international best practices in regard to the prevention of flaring? How can flaring be better addressed in Yellowtail? (E)	
Is ExxonMobil still flaring? (1)	
What was the cause of flaring and what was done? (V)	
More barrels of oil are to be produced from Yellowtail than current project and the issues around flaring need to addressed or the impacts from Yellowtail Project will be greater (6)	
Flaring mistakes need to be addressed (6)	
The flaring that falls under EPA EIA? Is it that same arrangement that we have for Liza 1, 2, and Payara – is this the same arrangement Guyana will have with the Yellowtail Project? (V)	

Comments (Consolidated)	Consideration in the EIA
With regards to flaring I'm wondering if the Oil Companies don't currently or immediately have the technology available in-house to cap the gas in the reservoir, and if not, how soon do you think the company will be able to obtain this technology? (V, E)	
Cumulative Impacts	
What are the cumulative impacts? (1,6, V)	Cumulative impacts are addressed in Chapter 10, Cumulative Impact Assessment, including consideration of the suite of EEPGL activities currently anticipated to occur during the Yellowtail Project life cycle.
A robust community cumulative Impact study will be done, will that study be done very soon and would it also include the last three projects and is there a timeline for having that done? (E, V)	
Cumulative impacts will include the past three that is a given; Will the cumulative impact assessment be done in a reasonable timeline because I am concerned that studies that were promised in the third project are still to be done? (V)	
We have had Liza 1, Liza 2, and Payara – the key issue is the cumulative impacts and how would this project consider these cumulative impacts in addition to Yellowtail. There would have been lessons learned from Liza 1, Liza 2, and how are those being considered in preparation for current Terms & Scope for Yellowtail? (V, E)	
With having third or fourth vessel: what is the combined effect of having four vessels operating? We have heard that there will be six or ten vessels. What is the combined effect of having four or more vessels in our waters? (V)	
I think it is important at this stage while looking at the specific associated direct and indirect impact from this project to take stock or have the EIA speak to the cumulative impacts to date in particular as it relates to associated emissions of GHG forecasted what would be associated emissions from Yellowtail and cumulatively (V)	Cumulative impacts are addressed in Chapter 10, Cumulative Impact Assessment. Section 10.6.1, Air Quality, Climate, and Climate Change, provides an assessment of potential cumulative impacts related to estimated GHG emissions for the combined EEPGL activities currently anticipated to occur during the Yellowtail Project life cycle.
With respect to liquid and solid waste that would be emitted, not just Yellowtail but whole system combined, there would be a daily and lifetime cumulative impact. Based on the permitted amount waste that is allowed, even if we used that number, what are the results of that? And will those be reported? What efforts are the government and companies making to take a close look and to recommend additional actions based on the results. (V)	Cumulative impacts are addressed in Chapter 10, Cumulative Impact Assessment. Section 10.6.3, Waste Management, provides an assessment of potential cumulative impacts related to estimated waste generation for the combined EEPGL activities currently anticipated to occur during the Yellowtail Project life cycle.

Comments (Consolidated)	Consideration in the EIA
Clearly the increase in the marine traffic with 4 projects will have an impact on marine life; are there plans to produce maps of prospective transport routes to and from the FPSO and the facilities on shore and the mitigating measure on the impacts on marine life. (Virtual)	Chapter 5, Scope of the Environmental Impact Assessment, includes a map of the Direct Area of Influence, which includes the marine/aviation transit corridor between the FPSO and the Guyana shorebases that will be used by the Project. Chapter 10, Cumulative Impact Assessment, discusses potential cumulative impacts on several resources from the anticipated cumulative marine vessel movements.
Water Quality Impacts	
What are the proposed discharges into the ocean? What are the impacts of those discharges on the environment? (E)	Chapter 2, Description of the Project, provides a summary of planned Project effluent discharges. Section 6.4, Marine Water Quality, and Appendix C, Water Quality Modeling Report, provide an assessment of potential Project impacts to marine water quality, including consideration of effluent discharges from planned Project activities.
Can studies be done on the components of the liquid waste discharges into ocean? (E)	
What is amount of produced water which will be released into the marine environment from the Yellowtail on weekly, monthly and annual basis and what will be the monthly average and daily maximum concentrations (mg/L) of total oil destined for ocean disposal? (E)	
Will the produced water in Yellowtail be dealt with the same way as in Liza 1? (E)	Chapter 2, Description of the Project, provides discussions of the design and operation—including monitoring—of the various discharge management systems on the FPSO. Chapter 13, Recommendations, and the ESMP summarize embedded controls incorporated into the Project design related to monitoring of effluent discharges to confirm adherence to discharge standards adopted by the Project.
What are the safety precautions taken to avoid toxic water from being dumped into Guyana waters? (6)	
Will ExxonMobil commit to re-injecting all of the produced water instead of dumping it and if not, will a study be done to consider the impact of this on Guyana's fisheries? (E)	
Are you dumping your produced water / waste water back into any of Guyana's waters and/or our EEZ? What strategy and method(s) will Yellowtail be using to minimize any harmful impact of produced water into Guyana EEZ Zone from the Yellow tail oil & gas operations? (E)	
Can you say if any of the following effective management strategies will be used in treating "Produced Water" in the Yellowtail operations in order to minimize risk of significant environmental harm, such as: the monitoring of discharge practices, materials used; restricted activities during peak reproductive periods; establishing of minimum buffer zones beyond the range of typical impacts - at least 2 km from any discharge points and surface infrastructure and 200 m from seafloor infrastructure with no expected discharges. (E)	
I am noting there are very big increases in vessels flying flags of convenience and we know that sometimes that means in terms of	

Comments (Consolidated)	Consideration in the EIA
liabilities in terms for any sort of marine pollution so I would hope that would be addressed as well. (V)	
We were told that a wastewater study would be done during the Payara development plan review, but we haven't heard anything since? (V)	Studies related to the produced water management for the Payara Project are being conducted independently of the Yellowtail Project EIA.
Concerned about the extremities of temperatures in waters offshore (6)	Noted.
Impact to fisheries and other marine life: it is not always clear what component of the waste streams might enter into the ocean and to what level, or what the scope of study involved. I know recently there was some information in the news about some of the turtles and other wildlife impacted by some unknown event that some were sick or died when they come on shore – doesn't mean it had anything to do with oil. But it should be looked at. What is the scope of studies that have taken place to evaluate those impacts? (V)	Baseline studies have been conducted for each of the marine taxa included in Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources (seabirds, marine mammals, riverine mammals, marine turtles, marine fish, and marine benthos) in the appropriate areas of the Guyana EEZ (in most cases the Stabroek Block and adjacent continental shelf, but in the Demerara River for riverine mammals). The results of the historical studies are summarized in the appropriate sections of Chapter 7; more recent studies are included in Volume II.
Acidity of waters offshore needs to be looked into. (6)	Section 6.4, Marine Water Quality, provides an assessment of existing conditions for marine water quality, based on the suite of environmental baseline studies conducted to date by EEPGL offshore Guyana, inclusive of measurement of ocean acidity (i.e., pH).
Managing environmental concerns re: production water and so on: in terms of how many million gallons of water and what will come from Yellowtail? Also, what is the position of the 4th production and how it will be dealt with? (V)	Chapter 2, Description of the Project, provides a summary of planned Project effluent discharges. Section 6.4, Marine Water Quality, and Appendix C, Water Quality Modeling Report, provide an assessment of potential Project impacts to marine water quality, including consideration of effluent discharges from planned Project activities.
Concerned that toxic water over long periods of time (20–30 years of production) is slowly poisoning fish (6)	Chapter 2, Description of the Project, provides a list of embedded controls and mitigation measures intended to address potential impacts on marine fauna (including fish) from effluents discharged to the Stabroek Block over time. The cumulative impact assessment analyzed the effects of simultaneous discharges from multiple production operations; these results are discussed in detail in Appendix C, Water Quality Modeling Report, and summarized in Section 10.6.2, Water Quality Modeling for Simultaneous Operations.
How does the Guyanese public know that the cleaned water is treated to the international standard before being discharged? (V)	The embedded controls and mitigation measures in Chapter 2, Description of the Project, include the applicable standards for effluent discharges. The cumulative impact assessment analyzed the effects of simultaneous discharges from multiple production operations; these results are discussed in detail in Appendix C, Water Quality Modeling

Comments (Consolidated)	Consideration in the EIA
	Report, and summarized in Section 10.6.2, Water Quality Modeling for Simultaneous Operations. The ESMP (included in Volume III) describes the monitoring measures proposed to verify compliance with these commitments.
Marine Life	
What is the impact of thermal energy on marine life? (V)	Section 6.4, Marine Water Quality, and Appendix C, Water Quality Modeling Report, assess the impact of thermal discharges on marine life.
What is the status of the studies that have been done on sea turtles, marine species, birds? (1)	Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources, includes discussion of baseline studies and existing conditions for biological resources, including marine life. Section 6.4, Marine Water Quality, and Appendix C, Water Quality Modeling Report, assess the impact of operational discharges on marine life.
Will Yellowtail operations have a baseline study done in order to measure, monitor and assess the impacts of discharge/produced water on marine life during the operation of the Yellowtail Project? (E)	
What will happen to turtles, fishes and crabs (and marine life in general) when Yellowtail commissions? The impacts on crab and fish should be studied in more detail (1, E)	Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources, assesses potential impacts on biological resources, including marine life.
Will ExxonMobil commit to re-injecting all of the produced water instead of dumping it and if not, will a study be done to consider the impact of this on Guyana's fisheries? (E)	
What is the impact of noise on marine wildlife in particular whales, dolphins, turtles and fish? Please differentiate by species.	
Project Description	
Is there a major difference between (or if there is what is the major difference) other than the size of the vessel with the current vessel we have out there right now? (V)	The Yellowtail FPSO will differ from the Destiny in that it will be based on a newly built barge-type vessel (vs. a converted tanker) and will feature waste heat recovery, vapor recovery, and compressor sparing systems for improved environmental and operational performance. Chapter 2, Description of the Project, provides additional details.
What kind of compressor will be used for YT? (6)	Chapter 2, Description of the Project, provides detailed descriptions of the Flash Gas Compression, Main Gas Compression, and Re-Injection Gas Compression Systems including compressor types.
Contingency for compressor issues on the YT FPSO. Actions and/or shut-down in event of compressor breakdown? (6, E)	Chapter 2, Description of the Project, describes lessons learned and the resulting inclusion of design and process improvements in the Project. For example, the Flash Gas Compression, Main Gas Compression, and Gas Re-injection systems will be equipped with spare compression capacity to reduce non-routine flaring duration. Additionally, there is an

Comments (Consolidated)	Consideration in the EIA
	increased focus on quality assurance / quality control activities in inspections at suppliers during equipment fabrication, surveillance during equipment preservation, and internal assessments during FPSO fabrication. Section 6.1, Air Quality, Climate, and Climate Change, discusses a flaring minimization plan EEPGL will develop for the Yellowtail Development Project.
What would be the cost of decommissioning of the Yellowtail project based on today's costs? Does EEPGL have the money to cover the costs of decommissioning? (E)	A Preliminary End of Operations Decommissioning Plan for Guyana Development Projects is provided in Volume III of the Yellowtail regulatory submittal.
How much equipment will be abandoned on the ocean floor? What is the impact on the environment of abandoning equipment on the ocean floor? (E)	Decommissioning and abandonment of subsea components of the Project are discussed in Chapter 2, Description of the Project, and in the Preliminary End of Operations Decommissioning Plan for Guyana Development Projects (provided in Volume III of the Yellowtail regulatory submittal). Associated potential impacts are discussed in Chapters 6 (Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources), 7 (Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources), and 8 (Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources).
Impacts to Environmental Resources	
What will be the effects on animal habitats? (1)	Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources, assesses potential impacts on biological resources, including impacts on coastal habitats, wildlife, and marine life.
Air Quality	
Is there a threshold limit set for emissions of specific components of gases that come from FPSO (VOCs)? (V, E)	Section 6.1, Air Quality, Climate, and Climate Change, describes the embedded controls and mitigation measures the Project will adopt to control emissions to the atmosphere, and summarizes the ambient air quality guidelines used for the assessment of potential impacts on air quality.
If emissions thresholds for FPSOs exist, are such limits set by the Guyana government or by the design basis submitted for the FPSO, or are they based just on equivalent tons of CO2 emissions? (V)	
Noise	
How many decibels of noise will the project generate, over what period of time? Please set out this information on a graph. (E)	Potential sound-related impacts are discussed in Section 6.2, Sound, in the resource-specific sections where potential underwater sound-related impacts to biological resources are discussed (Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources), and in Appendix H, Underwater Sound Modeling Report.

Comments (Consolidated)	Consideration in the EIA
Baseline Information	
Would be nice for us to be aware of the base line. (V)	Relevant baseline information, and a description of baseline studies, is provided in Chapters 6 (Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources), 7 (Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources), and 8 (Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources).
Waste Management	
Contractors and subcontractors will have a role to play onshore as it relates to those waste that cannot be treated on FPSO and I think it is necessary that those subcontractors projects are taken considered by the EPA independently I think it is useful for us to have a sense at minimum the expectation for the treatment of the waste that is being subcontracted and has to be treated onshore. (V)	Onshore treatment and disposal of waste produced by the Project is described in Chapter 2, Description of the Project, and Section 8.6, Waste Management Infrastructure Capacity. Additionally, the Project will manage its wastes in accordance with an approved Comprehensive Waste Management Plan (included in Volume III of the regulatory submittal).
How will EEPGL handle the toxic waste products to be discharged from this project since Guyana does not have the capabilities to deal with the same from the Liza Phase One Project alone?	
What are the expectations for treatment of waste which has to be subcontracted? Will the EIA forecast those? (E)	
Geology	
Impact evaluation of the area with respect to seismic zone whether or not it has already been included and to what level of risk is implied from that study of Seismic Zone? (V, E)	Section 5.2.1, Assessment of Potential for Geological/Seismic Impacts, provides an assessment of the potential for geological/seismic impacts.
Is the area prone to earthquakes? What about the possibility for earthquakes? (E, N/A)	
Protected Areas	
In your project Summary as it references Protected Areas, the project summary notes there will be no impact to protected areas however clearly that cannot be determined at this stage of the project. It is recommended that this resource / receptor be fully explored in the ESIA before arriving at conclusions as clearly those would influence mitigation plans and stakeholder involvement in the process. This will be handed in. (V)	The potential impacts on protected areas are considered in Section 7.1, Protected Areas and Special Status Species, for the Project and in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events, in relation to potential oil spill scenarios.

Comments (Consolidated)	Consideration in the EIA
Oil Spill Response	
How will EEPGL deal with an oil spill? How will EEPGL remove from the ocean the oil that surges into the ocean from a well blow out? What guarantee can you give that there would not be a spill? (6, E)	The Oil Spill Response Plan (included in Volume III of the regulatory submittal) details the processes and resources that EEPGL will implement in the unlikely event of an oil spill, including community involvement. Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events, addresses the potential risks to resources from various spill scenarios.
How will the community be involved in Oil Spill Response (OSR)? (NA)	
What Oil Spill Response measures are put in place in the community (1)	
How many boats and personnel will EEPGL have available for clean up? Is there sufficient response capability for a spill if it were to occur today? (E)	
National Oil Spill Plan has no compensation plan for fisher folk. If there is an oil spill, there needs to be compensation set out in law for fisherfolk (6)	Section 9.1, Unplanned Events Introduction, describes the claims and livelihood remediation processes that would be employed in the unlikely event of an oil spill causing losses to stakeholders, including fisherfolk.
Will you commit to having all costs incurred for restoration and compensation in the event of such a spill being deemed non-recoverable? (E)	
Can the TOR consider now that we are the fourth development project can we model various scenarios I have heard about spill response, we never know when it will happen, what will happen or scale that it will happen so can there be consideration of the worst-case scenario and possible implication modeling various dynamics that scientists can use? What will be the implication for seascape and landscape and coastline? Need to estimate the area possibly impacted if there is a spill, and estimate the associated economic fallout and livelihood implication considered in that. Also, what is the contingency if such an event should happen, not only in terms of physical impacts but also in terms of people's lives and fishing industry and fisherfolks and communities being affected? (V)	Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events, details the potential results of modeling various oil spill scenarios, including a Maximum Worst Case Discharge scenario and a Most Credible Worst Case Discharge scenario, under both unmitigated and mitigated scenarios. Impacts to both natural and socioeconomic resources (including livelihoods such as for fisherfolk) are described.
We will like to have potable water in case of spill because villages are using creeks and rivers (N/A).	
What would be the impact of oil on Guyana's coast and rivers, including the impact on marine and freshwater wildlife and ecosystems? Is it possible for oil to reach Guyana's coast and rivers? Will the coast be mapped as part of the oil spill response plan? (E)	
Can the Terms and Scope model various scenarios for the implications for the land and seascape in the event of an oil spill? (E)	

Comments (Consolidated)	Consideration in the EIA
Can EEPGL guarantee that there will be no well blowout? What measures are in place in the case of a blow out and how long will it take to cap? If a well blows out, how long will it take for EEPGL to bring a capping stack to the well? How long will it take for EEPGL to fit the capping stack to the well? Who will EEPGL employ to transport and fit the capping stack? (E)	Chapter 2, Description of the Project, describes the design elements and procedures that will be used to prevent a loss-of-well-control scenario. Chapter 2, Description of the Project, Chapter 13, Recommendations, and the ESMP summarize the various embedded controls incorporated into the Project design to prevent these scenarios. The Oil Spill Response Plan (included in Volume III of the regulatory submittal) details the processes that EEPGL will implement in the unlikely event of a loss-of-well-control, inclusive of deployment of a capping stack where appropriate.
Is there a plan for well blow-out incidents after decommissioning? (6)	The Preliminary End of Operations Decommissioning Plan for Guyana Development Projects, provided in Volume III of the regulatory submittal, describes the process for completion of decommissioning activities. Post-decommissioning procedures are a policy concern that is beyond the scope of the EIA.
Human Rights	
Approximately 1,000 fisherfolk covered by the Upper Corentyne Fishermen's Coop in the Berbice Area work under harsh and unstable conditions. (6)	Noted.
EIA Process and Stakeholder Engagement	
Consult villages that were not present at Region 1 meeting (1, E)	Engagement conducted in the development of this EIA is described in Section 4.7.2, Engagement to Date.
When will the EIA be complete? (V)	The public was notified of the EIA completion, and opportunities to review the EIA and engage with EEGPL and the Consultants, in accordance with the measures outlined in Section 4.7.4, Post-EIA Engagement.
While I respect the COVID taskforce restrictions; the 40 persons in Mabaruma will scarcely do any justice to the awareness and consultations process that is necessary for these very far flung riverine communities in Region 1 so even if you have to have deferred consultation process that you can manage the numbers with the COVID taskforce sets; I will be grateful for that because this has been a thorn in my side for the past three projects and I hoping we can fix it with Yellowtail project. (V)	EEPGL is committed to supporting public health and the wellbeing of all stakeholders as it pursues its engagement objectives. EEPGL and the Consultants engaged with Region 1 coastal communities during EIA development and disclosure, as described in Section 4.7, Stakeholder Engagement.

Comments (Consolidated)	Consideration in the EIA
To conform to the Free Prior and Informed Consent protocols that are a requirement for consultations with IP communities, you need to have them reasonably informed and give them the chance to ask questions and the radio will not afford the opportunities. (V)	Planned engagement, and engagement to date, is described in Section 4.7, Stakeholder Engagement, including information sharing and consultation with indigenous communities in Region 1 and other regions.
Continuous education is needed (E)	
Does EEPGL have LCO (Local Community Officer) on the ground to touch base with the communities? (No meeting information recorded)	EEPGL has an office in Georgetown. Contact information is provided in Section 4.7.1.3, Engagement Strategy.
Will lessons learned be incorporated into EIA? (V)	All sections of the EIA have benefited from the experience of past projects and engagement to date.
Other Socioeconomic Factors	
There were already consultation for the last 3 Projects, how the public will be aware of how their comments of the EIA for YT will be addressed? (1)	The outcomes of past engagement are summarized in Section 4.7, Stakeholder Engagement, and Volume III (SEP). Comments have also informed relevant sections of the EIA in Chapter 6 (Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources) through 10 (Cumulative Impact Assessment).
Is there the possibility of a joint committee between EM and communities (1)	Noted. Volume III (SEP) provides the current engagement program for EEPGL's operations in Guyana.
The Region 1 consultations were only held in Mabaruma; but the largest most significant indigenous community is in Santa Rosa area; could you provide clarity on if stakeholder consultations would actually engage with the most important indigenous populations in Region 1. (V)	Section 4.7, Stakeholder Engagement, describes stakeholder engagement activities undertaken as part of EIA disclosure, including engagement with Santa Rosa and other Region 1 communities.
More consultations in Region 1 villages is needed (1)	
Pass information to villages and communities in Morucca. (1)	
There needs to be increased engagements with coastal communities, especially the fisher folks. (E)	
EEPGL needs to go to communities and meet the 12 villages of Santa Rosa community for consultation. We need public to know about the Project, EPPGL must provide the information to the residents. (NA)	
EIA should include negative economic effects as well as positive effects. The ESIA should fully assess the negative impacts to the economy and the economic conditions and put appropriate mitigation measures. It only deals with positives. (V)	Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources, addresses potential socioeconomic impacts including potential positive and adverse economic impacts and measures designed to mitigate adverse impacts and support local benefits.
What will the benefits be to local communities? (1, E)	
Is Corporate Social Responsibility incorporated into the EIA (1, E)	

Comments (Consolidated)	Consideration in the EIA
What are the job opportunities for Guyanese? (6)	Section 8.2, Employment and Livelihoods, describes potential impacts on employment and livelihoods, including EEPGL's measures to support job opportunities for residents of Guyana.
How do the ocean currents work in relation to the shoreline, and do fisherfolk need to change their fishing routes? (6)	Sections 8.2, Employment and Livelihoods, and 8.4, Marine Use and Transportation, describe potential impacts associated with employment and livelihoods (including fisherfolk) and marine use, respectively.
Concerns were raised on the high volume of tankers and traffic that will be in the water and impacts on the fishing community. (E)	
Livelihoods	
Given the importance of the seafood industry to livelihoods and Guyana's GDP, what impact would this project have? (V)	Sections 8.2, Employment and Livelihoods, and 8.4, Marine Use and Transportation, describe potential impacts associated with employment and livelihoods (including fisherfolk) and marine use, respectively.
We are concerned about oil production/exploration and impacts on fisherfolk. (6)	
Compensation for Impacts	
Study needs to be done on our marine resources and a value needs to be put to it to determine compensation values (6)	Section 9.1, Unplanned Events Introduction, describes the claims and livelihood remediation processes that would be employed in the unlikely event of an oil spill causing losses to stakeholders, including fisherfolk. Sections 9.15, Socioeconomic Conditions / Employment and Livelihoods, through 9.23, Indigenous Peoples, assess potential impacts of an oil spill on socioeconomic topics including community health and wellbeing.
Will you compensate the fishermen if they suffer losses due to your operations?	
Who will compensate this country if there is a health issue due to the oil operations?	
We need law that stipulates compensation for fisherfolk (6)	
Will EEPGL pay compensation to the Caribbean islands for damage to their fishing and tourism industries?	Potential transboundary impacts are considered in Section 9.24, Transboundary Impacts.
Liability Concerns	
Will the Yellowtail project come with full coverage from the Parent Companies? (V)	Joint insurance coverage is obtained in the name of EEPGL and the other Stabroek block co-venturers for the appropriate lines of coverage, depending on the project and scope of work. Specifically for the Yellowtail Project, the co-venturers have insurance coverage including Third Party Liability and the cost of regaining control of a well.
Is Guyana fully protected by insurance? (E)	
Comments Directed at EPA	
Will the final parameters of the Terms of Scope of the EIA be shared with the public prior to same? And is there a period during wish members of the public may indicate additional concerns? (V)	The Terms and Scope are reflected in the contents of the EIA submitted to the EPA.

Comments (Consolidated)	Consideration in the EIA
This scoping exercise as well as submission of the questions (which we have already done) this exercise is supposed to answer. Will EPA inform the public? (V)	Section 4.7, Stakeholder Engagement, provides a summary of scoping engagement and comments received.
Has EPA evolved into the guardian of our environment? Have they filled existing gaps in personnel? (6)	Noted.
Guyana needs to have a well owner identification database for decommissioning – lessons need to be learned from the well blowout incident in Trinidad's Gulf of Paria (6)	Noted.
Questions [outside of the EIA Terms and Scope] are not answerable at this time, but the EPA should have clarified this process at the outset. (V)	Noted.
What interest rates will Guyana be faced with on this project's investment? What are the conditions under which these loans are being taken on?	Noted.
Outside the Scope of the EIA	
What profit did EEPGL make in 2020? (E)	Noted.
How much money will be set aside to pay for the costs of cleaning up? (E)	Noted.
Is there spillage occurring presently? (E)	Noted.
What are the socioeconomic benefits relative to sports etc? (E)	Noted.

EEZ = exclusive economic zone; EM = ExxonMobil; ESIA = Environmental and Social Impact Assessment; FPSO = Floating Production, Storage, and Offloading (vessel); GDP = gross domestic product; GHG = greenhouse gas; LCO = Local Community Officer; OSR = oil spill response; TOR = Terms of Reference; YT = Yellowtail

Note: The number in parentheses following the comment indicates the regional meeting at which the comment was made (Regions 1 through 6). "V" indicates the comment was made in a virtual meeting. "E" indicates that the comment was included in the summary of verbal and written comments provided by the EPA to EEPGL. "NA" indicates no meeting information was recorded.

Summary of Scoping Themes

The comments and suggestions received from stakeholders during the EIA scoping process (Table 4.7-4) were consolidated; Table 4.7-5 summarizes the broad themes of these comments and how they have been addressed in the EIA.

Table 4.7-5: Scoping Comments by Theme

Key Theme	Consideration in EIA
Socioeconomic impacts	• Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources, describes the assessment of potential socioeconomic impacts from planned Project activities. • Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events, describes the assessment of potential risks to socioeconomic resources from unplanned events (e.g., oil spills).
Environmental impacts	• Each resource/receptor-specific discussion in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources, and Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources, describes the assessment of potential impacts on environmental resources/receptors from planned Project activities and the management measures recommended to address those potential impacts. • Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events, describes the assessment of potential risks to environmental resources/receptors from unplanned events (e.g., oil spills).
Water quality impacts	• Chapter 2, Description of the Project, provides a summary of planned Project effluent discharges and various discharge management systems. • Section 6.4, Marine Water Quality, and Appendix C, Water Quality Modeling Report, provide an assessment of potential Project impacts to marine water quality
Regulatory process	• Chapter 3, Administrative Framework, describes the administrative framework applicable to the Project, including the regulatory process for the EIA. • Chapter 4, Methodology for Preparing the Environmental Impact Assessment, provides additional detail on the EIA process.
Unplanned events	• Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events, assesses potential risks from unplanned events, including oil spills. • The Oil Spill Response Plan, which is included as an attachment to the EIA, describes EEPGL's specific approach for managing the impacts of an oil spill, should one occur.
Project design, location, and schedule	• Chapter 2, Description of the Project, includes a description of the proposed Project and a schedule describing anticipated timing for the major stages of the Project, assuming receipt of regulatory approval to proceed.
Cumulative impacts	• Chapter 10, Cumulative Impact Assessment, assesses the potential cumulative impacts of the Project combined with the likely effects of other reasonably foreseeable activities with the potential to impact the same resources/receptors as the Project.

Key Theme	Consideration in EIA
Waste management	• Section 8.6, Waste Management Infrastructure Capacity, assesses potential impacts of planned Project activities on waste management infrastructure capacity. • Chapter 10, Cumulative Impact Assessment, assesses the potential cumulative impacts on waste management infrastructure capacity as a result of planned Project activities and other EEPGL activities. • A Comprehensive Waste Management Plan (included in Volume III of the regulatory submittal) describes EEPGL's strategy for addressing Project-generated wastes.
Stakeholder engagement	• Stakeholder engagement activities, including those with indigenous communities, are discussed in Section 4.7, Stakeholder Engagement, and a SEP is included as a part of this EIA in Volume III.

4.7.3.2. EIA Development

Table 4.7-6 summarizes the interviews, shared information, and other engagements conducted with respect to the Yellowtail Project during the EIA development stage including engagements in August and September 2021. The Consultants made efforts to engage with a broad representation of stakeholders including representatives of potentially vulnerable groups such as women, indigenous, disabled, or migrant populations; fishing cooperatives; other NDCs and RDCs; and various government agencies.

Table 4.7-6: Summary of Key Informant Interviews and Other Engagements for Yellowtail Development Project, 2021

Stakeholders	Summary of Engagement
Government Ministries, Departments and Other Agencies	
Ministry of Agriculture	• Acreage under coconut cultivation and baseline by 2025 • Annual production of coconuts and coconut water 2014–2020 • Annual production of roots, veg, fruits, spices 2014–2017
Hydromet	• Climatic variability data and trends 2018–2020
Fisheries Department Ministry of Agriculture	• Fishery prices: retail prices for different catch species in 2020 • Aquaculture fish yields, by species 2017–2020 • Fishery management measures the department may have taken in the past 2 years (gear restrictions, size limits, season closures, etc.) • Changes in demand for marine fish and shellfish in the last 2 years • Observed COVID-19-related changes in the fishing industry
National Agricultural Research Education Institute	• Provided reports and data on mangrove and other restoration efforts; Shell Beach erosion mitigation efforts; current and planned initiatives • Provided an update on the pandemic's impact on planned activities
National Trust Guyana	• Structure of the National Trust • Policy changes that could impact the Project's Chance Find Procedure
Ministry of Social Protection	• Updates regarding migrant populations in Guyana (Venezuelan and other migrants) and related humanitarian support efforts. • Business and training opportunities for vulnerable populations
Civil Defence Commission	• Civil Defence Commission's Updated (2020) Oil Spill Plan • Importance of local content for Project development, as well as independent surveying and assessment

Stakeholders	Summary of Engagement
Guyana Tourism Authority	• Covid-19 Tourism Impact Report • Financial Impact of Covid-19 on Tourism Sector • Guyana Hotel Occupancy • Visitor Arrivals by Month (year to date)
Ministry of Tourism, Industry and Commerce	• Gross domestic product by economic activity • Questions about possible positive externalities on economic sectors, including Project influence on infrastructure/institutional developments in Guyana, emerging industries and value-added products, attraction of investment to non-oil sectors, and labour market
NGOs	
Conservation International	• Mangrove restoration information • Concerns about climate impacts (including direct emissions), changes to ecosystems' ability to function for carbon sequestration, and ecosystem services for climate change adaptation • Concerns about flaring volumes • Importance of meaningful local community engagement • Importance of water quality testing around the FPSO (and the wider ecosystem) and extensive marine mammal surveys
Communities in Regions 1 through 6	
Almond Beach Community Development Council	• Community update including decline in tourism • Ecosystem services update including beach erosion, changing rainfall and water patterns; increasing frequency and severity of high tides • COVID-19 impacts including loss of Trinidad and Tobago coconut market • Protected Areas Commission Update—work continues with the commission
Aruka Mouth Community Development Council	• Ecosystem services update including changing weather and tide conditions. • Fishing update including increasing pirate attacks and reducing yields of fish
Barabina VC	• Ecosystem services update including higher than normal water levels • Fishing update including reducing yields due to increasing water levels • Hunting update including changing hunting patterns as animals recede further into the forest because of flooding
Gibraltar/Fyrish NDC	• Community update including increasing commodities prices, food insecurity and rising unemployment frustrating the villagers • COVID-19 impact including permanent closure of many small businesses • Flood impacts including significant loss of crops and livestock
Good Hope/ No. 5 Village NDC	• Flood impacts including significant loss of crops and livestock • Ecosystem services update including increase in mangrove cover because of less pressure from villagers' utilization
Hosororo Hill Community Development Council	• Community update including high unemployment; lack of investments in the community; and continued small-scale fishing and hunting. • Flood impact including agriculture (crops) and livestock devastated by the floods; food shortage and price increases.
Imbotero Community Development Council	• Community update including migration of immigrants; unemployment; shortage of drinking water; inadequate health facilities; and tourism development • COVID-19 and flood impacts and related increase in household poverty and debt

Stakeholders	Summary of Engagement
Kilcoy / New Hampshire NDC	• Flood impacts including approximately 3,500 households affected; significant loss of livestock; significant impact on livelihood; and residents' use of savings and loans to cope and rebuilt • COVID-19 impacts including significant impact on business and livelihood • Ecosystem services update including mangrove being re-grown
Kintrye NDC	• Community update including increased household expenditure due to increasing food and commodities prices • Flood impacts including damage to trails; significant loss of cultivation • COVID-19 impacts including increased youth unemployment • Ecosystem services update including mangrove being lost to sea erosion
Lancaster/Hogsty NDC	• Community update including high commodities prices and reduced standard of living in the villages • Concerns about oil spills and need for an oil spill emergency plan that addresses compensation for any losses suffered • Flood impacts including loss of livestock, cash crops and rice; damage to access dams and trenches; loss of investment and income; reduced spending power; and shortage of cash crops leading to increased prices • COVID 19 impacts on families psychologically, socially, economically
Leguan NDC	• Community update including lack of development; no investment; a stagnated economic environment; escalating prices; restricted growth; high unemployment; and declining population • COVID-19 impact including social, economic and mental health impacts • Flood impact was severe though not as bad as other parts of the country; rice farming, cash crop farming, and cattle farming were all somewhat affected but livelihoods largely maintained • Commodities prices have had a significant impact on the lower-middle income and low-income families; money does not go as far on the island and people continue to leave
Mon Repos / La Reconnaissance	• Harvesting of mangroves on seashore • Land use conflicts between local stakeholders on the seashore • Hike in prices of basic commodities creating food insecurity and causing familial conflicts including increased Gender Based Violence • Increase in solid waste management issues in the communities as a result of decreased capacity of the NDC
Morowhanna Community Development Council	• Community update including small scale fishing; no changes in marine activities; one report of piracy; migration increase • COVID-19 impact including businesses closing; money circulation reduced causing a slowdown in demand for produce from farmers in the community • Fuel trade has regularized as the border was re-opened with the vessels coming, the shortage eliminated, and the prices regularized
No. 52 / No. 74 NDC	• Fishing update including increase in fishing activity; a shift to Suriname

Stakeholders	Summary of Engagement
Parika NDC	• Flooding and COVID caused a slowdown of business in the community, increased debt and closure of some businesses • Ecosystem services update including concern for decreasing mangroves • Fishing update including reduced catch, supply reduced, and price increased
RDC Region 5	• Community update including escalating prices affecting ability to provide for family • Flooding has affected over 5,000 farmers with severe impacts on agriculture, particularly livestock rearing; significant loss of livelihood • COVID-19 impacts have forced some to change line of business • Some people have had to use savings, depend on families and the social and economic support programs from the Government • Fishing has been affected by fresh water flowing into the ocean, sargassum seaweed and land vegetation
Smith Creek Community Development Council	• Community update including impacts for houses are along the river (prone to flooding with every spring tide); the river is rising, further threatening families; • Local project to empolder a 100-acre (40.5 hectare) plot of land; desire for development to attract tourists; community has now gotten involved in the fuel trade
Unity/Vereeniging NDC	• Flood update including significant impact on agriculture especially cash crops, rice, and kitchen gardens • COVID-19 has affected all families financially, mentally, and socially • Commodities prices have increased and affect residents' ability to put food on the table • Project concerns related to oil spills, and need for a containment plan and to compensate for any losses suffered from any negative impact from this Project
White Water Village Community Development Council	• Community update including reduced spending power causing a slowdown in economic activities such as farming and fishing

4.7.3.3. EIA Disclosure and Review

The EIA Disclosure and Review period included nine public disclosure meetings (across each of the six coastal regions, and in virtual/online format), and a 60-day public comment period wherein any interested party could submit written comments on the EIA and its findings.

With the EPA, the Consultants have compiled a comprehensive account of the comments received during the public comment period (including comments documented at public disclosure meetings), and provided responses to each comment. In total, 449 distinct comments were documented during the comment period. The complete record of comments and responses is provided in Appendix U, Stakeholder Comments.

Many responses provided clarification and/or directed the reader to the appropriate section of the EIA where a comment is addressed. However, some responses resulted in an update or change to the EIA as summarized in Table 4.7-7.

Table 4.7-7: Summary of Changes to the EIA Related to Public Comments

EIA Chapter	Summary of Changes	Revised EIA Section(s)
Chapter 2, Project Description	Additional information was provided regarding the fact that Protected Species Observers will provide support to the Project; training and proficiency drills; slope stability analysis and strategies to address related concerns; procedures to manage radioactive sources; the potential to increase production over basic design rates; the frequency of hydrogen sulfide-focused training, if needed; gas reinjection and fuel gas consumption details; and gas compression pressure required for re-injection.	Section 2.3, Project Workforce Section 2.5.4, Well Control Section 2.7.1, General Description Section 2.10.2, Hydrogen Sulfide Management Section 2.13.5, Radiation Emission Sources Section 2.18.1, Location Alternatives Section 2.18.2, Development Concept Alternatives
Chapter 5, Scope of the Environmental Impact Assessment	Information was added regarding long-term noise exposure from vessel traffic.	Section 5.2.2, Assessment of Potential for Acoustic Impacts from Vessel Noise in Georgetown Harbour
Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources	Additional information was provided regarding: the basis on which ambient air monitoring locations were selected; limits used by EEPGL for occupational exposure; EEPGL's expressed willingness to engage with Government of Guyana agencies to progress environmental initiatives; factors that could contribute to air emissions differing from those estimated in the EIA; ExxonMobil's corporate plans regarding greenhouse gas emissions; and characterization of typical ambient underwater ocean sound levels.	Section 6.1.2.1, Existing Conditions—Air Quality Section 6.1.3.1, Relevant Project Activities and Potential Impacts Section 6.1.3.2, Emissions of Air Quality Pollutants Section 6.1.4, Management Measures—Air Quality, Climate, and Climate Change Section 6.2.2.2, Characterizing Existing Conditions in the PDA
Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources	Information was added to further explain how baseline data from 2020, 2019, and earlier are representative of current conditions; the beneficial impact from birds resting on vessels; maximum sound pressure levels to which mammals could be exposed; potential factors driving trends in fish production; the effects on pelagic fish approaching the FPSO; and the effects of the Project on regional current patterns.	Section 7.3.2, Existing Conditions—Coastal Wildlife Section 7.4.2, Existing Conditions—Seabirds Section 7.4.3, Impact Assessment—Seabirds Section 7.5.3, Impact Assessment—Marine Mammals Section 7.6.2, Existing Conditions—Riverine Mammals Section 7.7.2, Existing Conditions—Marine Turtles Section 7.8.2, Existing Conditions—Marine Fish Section 7.8.3, Impact Assessment—Marine Fish Section 7.9.2, Existing Conditions—Marine Benthos
Chapter 8, Assessment and Mitigation of Potential Impacts from Planned	Provided additional context for the focus of mitigation measures on impacts with a predicted significance of minor or higher; updated the discussions of the SES waste management	Section 8.5.4, Management Measures—Social Infrastructure and Services

EIA Chapter	Summary of Changes	Revised EIA Section(s)
Activities—Socioeconomic Resources	facility to reflect its current and planned operational status.	Section 8.6.2, Existing Conditions—Waste Management Infrastructure Capacity Section 8.6.3, Impact Assessment—Waste Management Infrastructure Capacity Section 8.8.4, Management Measures—Land Use
Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events	Supplemented the discussion to confirm that the production-related spills scenario covers all modes of offloading hose failure; added information that in the event that the sewage treatment plant is not operating properly and wastewater is temporarily discharged outside of specification limits, the manner in which the wastewater stream would be managed until the sewage treatment plant is repaired; clarified that assessment of vessel collisions with marine mammals considers all those vessels that would support the Project.	Section 9.1.1, Hydrocarbon Spill Section 9.1.11, Discharge of Untreated Wastewater from the FPSO Section 9.9.4, Vessel Collision

4.7.4. Post-EIA Engagement

Once the EIA process is complete, and assuming EEPGL obtains an environmental authorization and other approvals from the EPA, the Project will transition into execution. Plans for stakeholder engagement during Project execution are described in the SEP, and engagement activities will be adjusted to reflect evolving Project status and activity level, as well as stakeholder concerns over the life of the Project (at least 20 years).

During Project execution, the emphasis of engagement shifts from input gathering to disclosure about planned activities, receiving feedback from members of the public and other stakeholders, and consultation about ongoing and planned activities. EEPGL will keep the public informed about the general progress of the Project (e.g., completion of Project stages such as development well drilling) and will respond to any grievances (i.e., specific complaints) filed under the Project's Grievance Procedure, which is described in the SEP. The Grievance Procedure will be maintained throughout the life of the Project (at least 20 years).

4.8. Assessment of Impacts and Identification of Mitigation Measures

The primary purposes of an EIA are to predict the potential impacts resulting from a proposed project and identify measures to avoid, reduce, or remedy these potential impacts. The Consultants used a standard impact assessment methodology, aligned with the requirements of the EPA Guidelines, for identifying potential impacts and assessing their significance.

Potential impacts include impacts on physical, biological, and socioeconomic resources and can be “direct,” “indirect,” or “induced,” as defined below:

- Direct—impacts that result from a direct interaction between a project and a resource/receptor (e.g., disturbance of a benthic community habitat on the seafloor);
- Indirect—impacts that follow from direct interactions between a project and other resources/receptors (e.g., impacts on marine fishes that feed off a directly impacted benthic community); and
- Induced—impacts that result from other non-Project activities that occur as a consequence of a project (e.g., impacts from an influx of job seekers).

The assessment of impacts proceeded through an iterative four-step process, as illustrated on Figure 4.8-1.

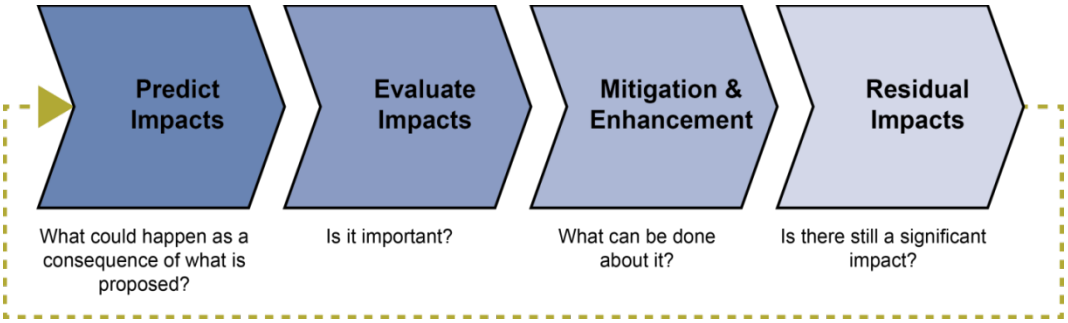


Figure 4.8-1: Impact Prediction and Evaluation Process

4.8.1. Step 1: Predict Impacts

The EIA evaluates potential Project impacts by predicting and quantifying, to the extent possible, the magnitude of those impacts on resources/receptors and the sensitivity/vulnerability/importance of the impacted resources/receptors.

4.8.1.1. Predicting Magnitude of Impacts

Magnitude essentially describes the nature and degree of change that the potential impact is likely to impart upon the resource/receptor. Depending on the impact, magnitude is a function of some or all of the following impact characteristics:

- Geographical extent
- Intensity
- Frequency
- Duration

The magnitude of an impact takes into account the various dimensions of a particular impact to determine where the impact falls on the spectrum (in the case of adverse impacts) from **Negligible** to **Large**. Some impacts will result in changes to the resource/receptor that may be immeasurable or undetectable. Such changes are characterized as having a **Negligible** magnitude.

Taking into account the magnitude of impact characteristics identified above, the magnitude of each potential impact is assigned one of the following five ratings:

- Positive
- Negligible
- Small
- Medium
- Large

Based on prior stakeholder input received and modeling performed during the EIAs for the Liza Phase 1, Liza Phase 2, and Payara development projects, each potential impact was characterized by one of three possible geographical extents:

- Direct AOI
- Direct AOI + Central Stabroek Block
- Indirect AOI

The Direct and Indirect AOIs are defined and depicted in Section 5.1, The Area of Influence, of the EIA. Specifically, maps of the Direct and Indirect AOIs are included as Figures 5.1-1 and 5.1-2, respectively. The “Direct AOI + Central Stabroek Block” designation for geographical extent is not intended to designate a specific bounded area; rather, it is intended to capture the geographical extents of impacts that are likely to extend slightly outside of the Direct AOI, but well short of the limits of the Indirect AOI (e.g., underwater sound disturbance impacts on marine mammals).

The definitions for duration and frequency designations used throughout the EIA are provided in Tables 4.8-1 and 4.8-2, respectively.

Table 4.8-1: Definitions for Duration Designations

Duration Designation	Definition
Short-term	Instantaneous to less than an week in aggregate
Medium-term	More than a week but less than a year in aggregate
Long-term	More than 1 year in aggregate

Table 4.8-2: Definitions for Frequency Designations

Frequency Designation	Definition
Episodic	Occurring occasionally and at irregular intervals
Continuous	Occurring more than occasionally or at regular intervals

Recognizing that the same impact could be experienced differently by different resources/receptors, the definitions for intensity designations are described in the resource/receptor-specific sections of the EIA (Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources).

To establish a consistent basis for assigning magnitude ratings based on the various impact characteristics (i.e., geographical extent, intensity, frequency, and duration), each of the possible combinations of characteristic designations was assigned a magnitude rating. Figure 4.8-2 lists the various combinations of impact characteristics and the corresponding magnitude ratings that were assigned for each combination.

Direct AOI			
Intensity	**Frequency**	**Duration**	**Overall Magnitude Rating**
Negligible	Episodic	Short-term Medium-term	Negligible
Low	Episodic	Short-term	Negligible
		Medium-term	Small
Medium	Episodic	Short-term	Negligible
		Medium-term	Small
High	Episodic	Short-term	Medium
		Medium-term	Medium
Negligible	Episodic	Long-term	Negligible
Low	Episodic	Long-term	Small
Medium	Episodic	Long-term	Small
High	Episodic	Long-term	Medium
Negligible	Continuous	Short-term Medium-term	Negligible
Low	Continuous	Short-term	Small
		Medium-term	Small
Medium	Continuous	Short-term	Small
		Medium-term	Medium
High	Continuous	Short-term	Medium
		Medium-term	Medium
Negligible	Continuous	Long-term	Negligible
Low	Continuous	Long-term	Small
Medium	Continuous	Long-term	Medium
High	Continuous	Long-term	Large

Direct AOI + Central Stabroek Block			
Intensity	**Frequency**	**Duration**	**Overall Magnitude Rating**
Negligible	Episodic	Short-term Medium-term	Negligible
Low	Episodic	Short-term	Negligible
		Medium-term	Small
Medium	Episodic	Short-term	Small
		Medium-term	Small
High	Episodic	Short-term	Medium
		Medium-term	Medium
Negligible	Episodic	Long-term	Negligible
Low	Episodic	Long-term	Small
Medium	Episodic	Long-term	Medium
High	Episodic	Long-term	Medium
Negligible	Continuous	Short-term Medium-term	Negligible
Low	Continuous	Short-term	Small
		Medium-term	Small
Medium	Continuous	Short-term	Small
		Medium-term	Medium
High	Continuous	Short-term	Medium
		Medium-term	Large
Negligible	Continuous	Long-term	Negligible
Low	Continuous	Long-term	Small
Medium	Continuous	Long-term	Medium
High	Continuous	Long-term	Large

Indirect AOI			
Intensity	**Frequency**	**Duration**	**Overall Magnitude Rating**
Negligible	Episodic	Short-term Medium-term	Negligible
Low	Episodic	Short-term	Small
		Medium-term	Small
Medium	Episodic	Short-term	Small
		Medium-term	Medium
High	Episodic	Short-term	Medium
		Medium-term	Large
Negligible	Episodic	Long-term	Negligible
Low	Episodic	Long-term	Small
Medium	Episodic	Long-term	Medium
High	Episodic	Long-term	Large
Negligible	Continuous	Short-term Medium-term	Negligible
Low	Continuous	Short-term	Small
		Medium-term	Small
Medium	Continuous	Short-term	Medium
		Medium-term	Medium
High	Continuous	Short-term	Medium
		Medium-term	Large
Negligible	Continuous	Long-term	Negligible
Low	Continuous	Long-term	Small
Medium	Continuous	Long-term	Large
High	Continuous	Long-term	Large

Figure 4.8-2: Impact Characteristics and Magnitude Ratings

4.8.1.2. Predicting Sensitivity, Vulnerability, or Importance of Impacts

Multiple factors are taken into account when defining the sensitivity/vulnerability/importance of a resource/receptor. For physical resources (e.g., marine water quality), the resource's sensitivity to change is typically considered. For biological or cultural resources/receptors (e.g., a mangrove forest), the importance (e.g., local, regional, national, or international importance) and sensitivity to the specific type of impact are typically considered. For human receptors, the vulnerability of the potentially impacted individual, community, or wider societal group is generally considered. Other factors may also be considered when characterizing sensitivity/vulnerability/importance, such as legal protection, government policy, stakeholder views, and economic value. Depending on the resource/receptor being considered, the EIA focuses on the factor (i.e., sensitivity, vulnerability, or importance) that is most relevant to that resource/receptor. However, for ease of reference, this factor is typically referred to hereinafter as "sensitivity."

As in the case of magnitude, the approach for designating sensitivity ratings will vary on a resource/receptor basis. The following sensitivity designations are used in the EIA:

- Low
- Medium
- High

Not all resources can be assessed according to the same criteria, so the sensitivity ratings for specific resources/receptors may be determined differently according to the resource/receptor (or the type of impact) being assessed. The specific criteria used to assign sensitivity ratings are therefore discussed in the resource/receptor-specific sections (Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources).

4.8.2. Step 2: Evaluate Impacts

The process of impact evaluation considers predicted impacts with the potential to occur due to planned activities of the Project, and impacts that could potentially occur due to unplanned events (e.g., oil spills), but would not otherwise be expected to occur as a result of planned Project activities.

4.8.2.1. Evaluating Potential Impacts from Planned Activities

For potential impacts associated with planned activities of the Project, the significance of each potential impact is assigned based on evaluation of the magnitude of the impact and the sensitivity/vulnerability/importance of the resource/receptor. The matrix depicted on Figure 4.8-3 is used for assigning impact significance ratings. The assignment of a significance rating enables decision-makers and stakeholders to understand and prioritize key potential Project impacts and consider what mitigation measures may be warranted.

		Sensitivity/Vulnerability/Importance of Resource/Receptor		
		Low	Medium	High
Magnitude of Impact	Negligible	Negligible	Negligible	Negligible
	Small	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	Large	Moderate	Major	Major

Figure 4.8-3: Impact Significance Rating Matrix for Planned Activities

An impact of **Negligible** significance is one where a resource/receptor will not be noticeably impacted by a particular activity; the predicted impact is deemed to be imperceptible or is indistinguishable from natural background variations, or the impact is of a small magnitude and is expected to affect resources/receptors with a low sensitivity to the particular impact.

An impact of **Minor** significance is one where a resource/receptor will experience a noticeable effect, either due to a small magnitude impact affecting a resource/receptor with a medium sensitivity or due to a medium magnitude impact affecting a resource/receptor with a low sensitivity. In either case, the magnitude is expected to be within applicable standards, if any exist.

An impact of **Moderate** significance has an impact magnitude that is within applicable standards (if any exist), but falls somewhere in the range from an effects threshold below which the impact is considered Minor, and above which the impact is considered Major.

An impact of **Major** significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts are predicted to affect resource/receptors that have a medium or high sensitivity.

In the case of positive impacts, the EIA does not attempt to characterize magnitude; therefore, significance ratings for positive impacts are not assigned.

The specific criteria used to evaluate significance of impacts for each resource/receptor are presented in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from

Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources.

4.8.2.2. Evaluating Potential Impacts from Unplanned Events

Potential risks from non-routine/unplanned events related to the Project (e.g., oil spills, traffic accidents, or other events with a less-than-certain chance of occurrence) do not lend themselves readily to the analysis described above for planned Project activities. Rather than assigning significance ratings (as is done for potential impacts from planned activities), the EIA assigns risk ratings for potential risks from unplanned events. Assessing risk requires understanding:

- Potential consequence/severity of the unplanned event if it were to occur; and
- Likelihood of the unplanned event occurring.

For unplanned events, a risk matrix (Figure 4.8-4) is used to rate the risk to resources associated with these events.

		Consequence/Severity		
		Low	Medium	High
Likelihood	Unlikely	Minor	Minor	Moderate
	Possible	Minor	Moderate	Major
	Likely	Moderate	Major	Major

Figure 4.8-4: Risk Rating Matrix for Unplanned Events

Likelihood reflects the probability of occurrence of the unplanned event, and is defined as follows:

- Unlikely—considered a rare event; there is a small likelihood that such an event would occur during the Project life cycle;
- Possible—the event has a reasonable chance to occur at some time during normal operations of the Project; and
- Likely—the event is expected to occur at some point during the Project life cycle.

Likelihood is estimated on the basis of experience and/or evidence that such an outcome has previously occurred. It is important to note that likelihood is a measure of the degree to which the unplanned event is expected to occur, not the degree to which an impact is expected to occur as a result of the unplanned event. The latter concept is referred to as uncertainty, and this is typically dealt with in a contextual discussion in the impact assessment, rather than in the risk rating process.

The consequence/severity element of the risk rating is assigned based on the sensitivity of the resource/receptor and the magnitude of the impact (determined as if it were an impact from a planned activity)—essentially equivalent to the manner in which a significance rating is assigned for an impact from a planned activity—and then using Figure 4.8-5 to determine the assigned consequence/severity.

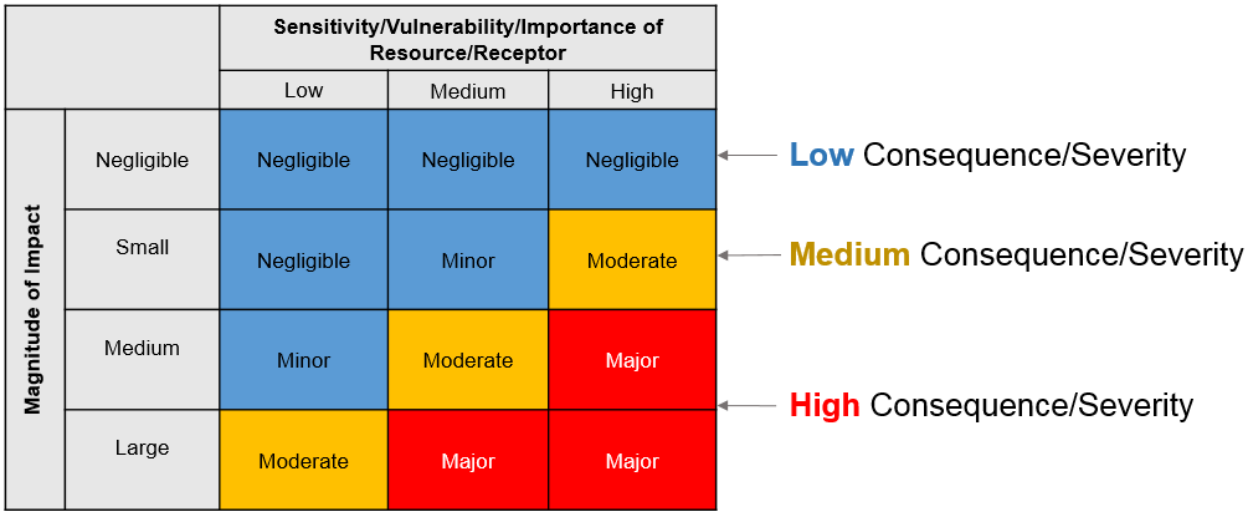


Figure 4.8-5: Consequence/Severity Determination for Unplanned Events

4.8.3. Step 3: Mitigation and Enhancement

The next step in the process is the identification of measures that can be taken to mitigate, as far as reasonably practicable, the identified potential impacts of the Project. A mitigation hierarchy is used, where the preference is always to avoid the impact before considering other types of mitigation. The following is the preferred hierarchy of measures followed in this EIA:

- Avoid—remove the source of the impact by employing alternative designs or operations to avoid potential adverse interactions with environmental and socioeconomic resources/receptors;
- Reduce—lessen the chance of adverse interaction between the Project and resources/ receptors and/or lessen the consequence of adverse interactions that cannot be avoided (e.g., reduce the size of the Project footprint); and
- Remedy—if adverse interactions between the Project and resources/receptors cannot be avoided or their consequences reduced, then “repair” the consequences of the impact after it has occurred through rehabilitation, reclamation, restoration, compensation, and/or measures.

In support of the EIA process, the Consultants and EEPGL developed an adaptive management strategy to aid in tracking, in which committed mitigation measures are implemented as planned and produce the desired outcomes. This adaptive management strategy provides EEPGL, in consultation with the EPA and other stakeholders, the opportunity to:

- Address unanticipated adverse impacts that are encountered—by identifying and implementing new or different mitigation measures (following the same avoid/reduce/ remedy hierarchy);

- Adjust or replace existing mitigation measures when appropriate during the Project life cycle—to address evolving impacts; and
- Retire existing mitigation measures that no longer demonstrate value.

Mitigation measures were developed where appropriate to address potential impacts identified in the EIA process. These measures are described in each resource/receptor-specific discussion in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources. Chapter 13, Recommendations, summarizes all of these mitigation measures. Mitigation measures are generally not developed for potential adverse impacts that are assessed as having a significance rating of **Negligible**.

In addition, an ESMP was prepared that describes all the mitigation measures incorporated into the EIA, summarizes how each mitigation measure will be implemented, and identifies a monitoring strategy to evaluate the effectiveness of each mitigation measure. The ESMP is included as an attachment to the EIA.

EEPGL recognizes that demonstrating capacity to manage non-routine, unplanned events, such as oil spills, is an important and integral component of the impact management process. As such, the ESMP includes an Oil Spill Response Plan to address the management of potential impacts resulting from an unplanned oil spill.

4.8.4. Step 4: Determine and Manage Residual Impacts

The final step in the iterative impact evaluation process for this EIA is the assessment of "residual impacts/risks" (i.e., impacts/risks that are predicted to remain after both embedded controls and committed mitigation measures have been taken into consideration). This typically involves repeating the process described in Step 1 and Step 2 to re-evaluate the potential impact significance or risk rating, considering the implementation of proposed mitigation measures.

In cases where the residual impact significance rating or the residual risk rating is **Moderate** or **Major**, the management emphasis is on reducing the impact/risk to a level that is as low as reasonably practicable. This does not necessarily mean, for example, that residual impacts/risks of **Moderate** or higher have to be reduced to **Minor**, but rather that these impacts/risks are being managed as effectively and efficiently as practicable.

Although a standard goal of an impact assessment is to eliminate residual impacts/risks of a **Major** significance, for some resources/receptors, there may be residual impacts/risks of **Major** even after all practicable mitigation options have been exhausted. In these situations, decision-makers must weigh negative factors against the positive ones, in reaching a decision on the Project.

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5. SCOPE OF THE ENVIRONMENTAL IMPACT ASSESSMENT

The scope of the EIA includes all Project stages described in Chapter 2, Description of the Project (i.e., development drilling; marine installation, hook-up, commissioning and start-up; production operations; and decommissioning) and all planned activities listed in Section 5.1, The Area of Influence. The EIA also addresses non-routine, unplanned events (e.g., spills and releases). The EIA builds on a number of EIAs and environmental management plans (EMPs), including the following:

- 2014—Strategic Environmental Assessment, assessing exploration drilling impacts and mitigations in Liza and Sorubim areas of interest within the Stabroek Block (ERM 2014);
- 2015—Strategic Environmental Assessment Addendum, continuing to assess exploration drilling impacts and mitigations following the Liza discovery and supporting the drilling of the Liza-2 well (ERM 2015);
- 2016—EMP, assessing additional multiwell exploration drilling impacts, management and mitigation measures within Stabroek Block (ERM 2016);
- 2017—Liza Phase 1 Development Project EIA, assessing development wells, associated development infrastructure, production operations, and decommissioning in the Liza Phase 1 area of interest (ERM 2017);
- 2018—EMP Addendum, assessing additional multiwell exploration drilling impacts within the Stabroek Block (ERM 2018b);
- 2018—Liza Phase 2 Development Project EIA, assessing development wells, associated development infrastructure, production operations, and decommissioning in the Liza Phase 2 area of interest (ERM 2018a);
- 2019—EMP, assessing additional multiwell exploration drilling impacts and mitigations across several areas of interest in the Stabroek Block (ERM 2019);
- 2020—Environmental Assessment and Management Plan (EAMP), assessing multiwell exploration drilling impacts and mitigations in the Canje Block (ERM 2020a);
- 2020—EAMP, assessing multiwell exploration drilling impacts and mitigations in the Kaieteur Block (ERM 2020b); and
- 2020—Payara Development Project EIA, assessing development wells, associated development infrastructure, production operations, and decommissioning in the Payara area of interest (ERM 2020c).

Supplementing the studies and analyses conducted as part of the above assessments, additional data collection and further analyses were conducted to evaluate the potential environmental and socioeconomic impacts of the Project, and these are discussed herein.

5.1. THE AREA OF INFLUENCE

The area potentially impacted by a project is referred to as its Project Area of Influence (AOI). For purposes of this EIA, a Direct AOI and an Indirect AOI were defined, as described below:

- Direct AOI, within which the Project is expected to have potential direct impacts (Figure 5.1-1). This area includes: (1) the Project Development Area (PDA) (i.e., the subsea development area including the wells, Subsea, Umbilicals, Risers, and Flowlines [SURF] equipment, and other subsea infrastructure; and the surface development area including the Floating Production, Storage, and Offloading [FPSO] vessel, drill ships, other Project marine vessels and associated marine safety exclusion zones); (2) the marine and aviation transit corridors between the PDA and onshore activity centers in Guyana; and (3) the City of Georgetown. These areas collectively were defined as the Direct AOI because they comprise, based on the potential impacts identified during the scoping phase, the geographic extent in which direct Project impacts (i.e., potential impacts resulting from a direct interaction between planned Project activities and environmental or socioeconomic resources are anticipated to potentially occur. The planned Project activities will generate emissions to air and discharges to water, which could result in potential impacts on air quality and water quality, respectively, outside of the geographic extent encompassed by the Direct AOI. Modeling for these parameters was conducted to assess whether these emissions and discharges could result in potential impacts on air quality and water quality, respectively, outside of the geographic extent encompassed by the Direct AOI. The results of modeling (see Sections 6.1.3, Impact Assessment—Air Quality, Climate, and Climate Change, and 6.4.3, Impact Assessment—Marine Water Quality) confirmed that the Direct AOI is inclusive of the extent of potentially significant impacts on these resources.
- Indirect AOI, within which the Project is expected to have potential indirect impacts or could have impacts from an unplanned event (Figure 5.1-2). This area includes: (1) coastal areas and marine waters within the territorial boundary of Guyana that could potentially be impacted by an unplanned event (i.e., an oil spill [see Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events, for more details on oil spill modeling]); and (2) coastal Regions 1 through 6, which could be impacted to a greater extent than other regions because of their degree of reliance on subsistence and commercial marine fisheries (i.e., related to potential impacts on fish and marine transport) and increased exposure to potential Project socioeconomic impacts. Although all ten regions of Guyana will potentially benefit from the shared government revenue stream from the Project, the Indirect AOI does not include the entire country because the extent to which any specific region could benefit from the revenues is dependent on the government's policies rather than on the Project activities assessed in this EIA. Based on oil spill modeling conducted for the Yellowtail Development Project, only (portions of) the Region 1 and Region 2 coastlines could potentially be impacted by a spill. This modeling also indicates an oil spill would not have a

reasonable likelihood of affecting marine waters southeastward or seaward of the FPSO. However, considering the potential for community members from all coastal regions (in particular fisherfolk and other marine users) to be indirectly affected in the event of an oil spill, as well as the potential for socioeconomic impacts from some planned Project activities (e.g., Project vessel movements), all six coastal regions and the entire extent of Guyana's marine waters downgradient of the FPSO were defined collectively as the Indirect AOI. While the Indirect AOI is limited to the territorial boundaries of Guyana, the potential for impacts from an unplanned event outside this area are addressed in Section 9.24, Transboundary Impacts.

As described in Chapter 10, Cumulative Impact Assessment, cumulative impacts on environmental and socioeconomic resources could potentially result from incremental impacts of the Project, when combined with other past, present, and reasonably foreseeable future projects/ developments within the Project AOI. The geographic area of concern for the cumulative impacts analysis is generally consistent with the Project AOI.

To define the scope of the environmental and socioeconomic impact analysis, it is necessary to identify the potential interactions between the Project and the resources/receptors within the Project AOI. These interactions are the mechanisms that could trigger Project-related impacts on resources/receptors.

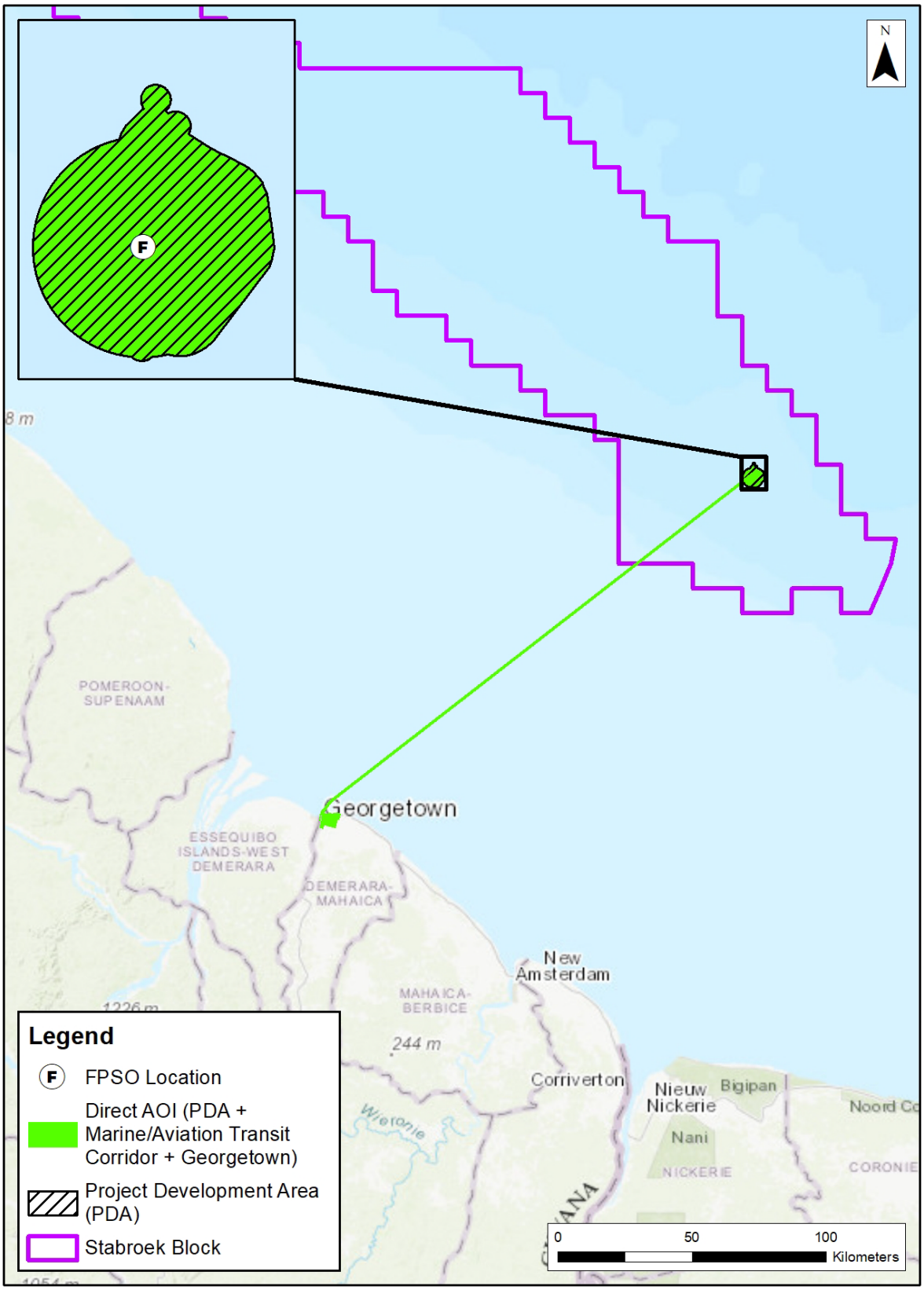

Figure 5.1-1: Direct Area of Influence

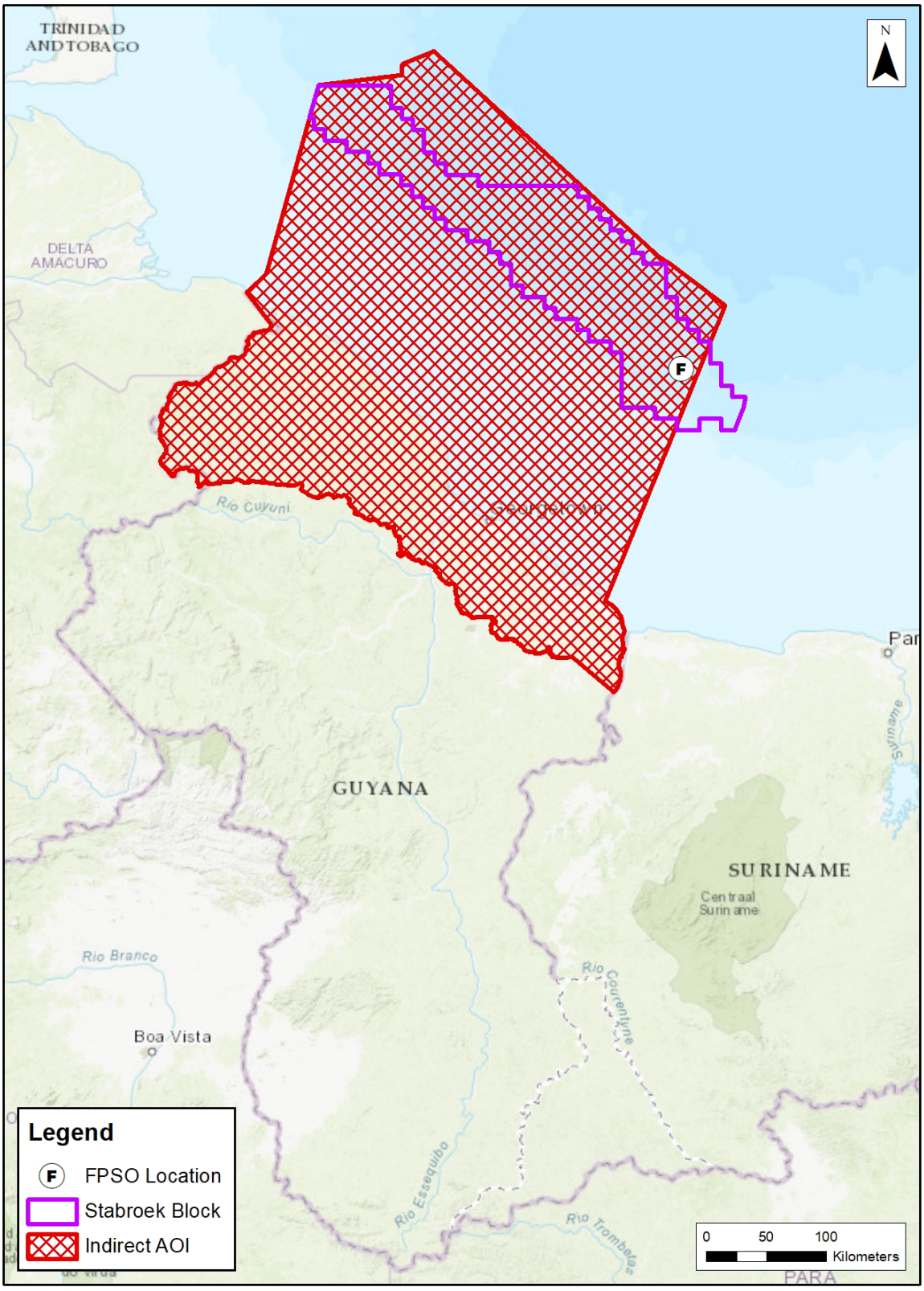

Figure 5.1-2: Indirect Area of Influence

The Project activities and potential unplanned events listed below may potentially interact with existing resources/receptors, and these interactions could potentially create direct, indirect, or cumulative environmental or socioeconomic impacts:

- Development drilling stage
  - Drill ship and drilling operations
    - Power generation
    - Drill cuttings discharges
    - Drilling fluids discharges
    - Effluent discharges
  - Vertical Seismic Profiling operations
  - Remotely operated vehicle operations
- Marine installation, hook-up, and commissioning stage:
  - FPSO
    - Power generation
    - Installation of FPSO mooring system
    - Discharge of hydrostatic test water, hydrate inhibitor, and ballast water
    - Effluent discharges
  - Installation of SURF equipment including remotely operated vehicle operations
  - Installation of FPSO/SURF components stage
  - Hook-up and commissioning of FPSO and SURF equipment
- Start-up stage:
  - Gas Turbine Generators, on marine gas oil
  - Utilities
  - Oil systems
  - Main Gas Compression
  - Gas Turbine Generators on fuel
  - Flash Gas Compression
  - Injection Gas Compressor
  - Seawater treatment injection systems
  - Produced water treatment
  - Limited flaring
- Productions operations stage:
  - FPSO Vessel Operations
    - Power and heat generation
    - Safety flaring, including pilot, purge, and supplemental, as applicable
    - Non-routine, temporary flaring
    - Treated produced water discharge
    - Brine discharges from sulfate removal, ultrafiltration, and wash water processing
    - Treated sanitary wastewater discharge

        - Ballast water discharge (one time at mobilization)
        - Non-hydrocarbon (non-contact) cooling water discharges
        - Gas re-injection into reservoir
        - Seawater intake
        - Treated seawater injection into reservoir
        - Chemical use (topsides, subsea, downhole)
    - Oil storage and offloading to conventional tankers
        - Tanker power generation
        - Venting of cargo tanks during oil loading
        - Seawater intake for ballast operations
        - Tanker ballast water discharge on arrival
        - Tanker treated domestic wastewater discharge
- Decommissioning stage
    - Marine decommissioning vessels and FPSO
        - Power generation
        - Treated sanitary wastewater discharges
    - Well plugging and abandonment
    - Disconnection of mooring system and SURF equipment
- Logistical support (across all Project stages)
    - Supply and support vessel/aircraft operations
    - Onshore and offshore fuel transfers from suppliers
    - Utilization of shorebases, including pipe yards and warehouses
- Waste management, recycling, treatment, and disposal (across all Project stages)
    - Onshore waste management, segregation, recycling, reuse, treatment, and/or disposal
    - Offshore waste treatment and disposal, potentially including waste incineration
- Non-routine, unplanned events
    - Oil spill or release—FPSO/SURF (during start up and/or production operations)
    - Oil spill or release—loss-of-well-control event
    - Other oil spills or releases
    - Other unplanned events (e.g., vehicular accident, helicopter accident, vessel collision, untreated wastewater discharge)

Ancillary activities or facilities (e.g., shorebases) that are not components of the Project but are associated with the Project also may potentially interact with existing resources/receptors, and these interactions could potentially create induced environmental or socioeconomic impacts. EEPGL will use existing onshore facilities owned and operated by others (noting that none of these will be Project- or EEPGL-dedicated facilities). Where EEPGL has obligations to ensure its employees and its contractors are working within regulatory requirements and the measures established in the EIA and related Environmental Permit conditions, the EIA discusses measures to ensure conformance with these requirements.

5.2. RESOURCES/RECEPTORS ASSESSED IN THE EIA

One of the purposes of the scoping process is to identify which resources/receptors could potentially be significantly impacted by the Project and which resources/receptors would not have the potential to be significantly impacted by the Project. Based on the Project description and understanding of existing conditions at the time of scoping, Table 5.2-1 lists those resources/receptors that were identified as having the potential to be significantly impacted by the Project, subject to further assessment. These resources/receptors were retained for further consideration in the EIA.

Table 5.2-2 lists those resources/receptors that were identified as being unlikely to have the potential to be significantly impacted by the Project and the rationale for this determination. These resources/receptors were excluded from further consideration in the EIA.

Table 5.2-1: Summary of Resources/Receptors, Potential Impacts, Sources of Potential Impacts, and Assessment Approach

Resources/Receptors	Potential Impact	Primary Sources of Potential Impacts	Assessment Approach
Physical Resources			
Air Quality, Climate, and Climate Change	Air emissions resulting from the Project have the potential to change ambient air quality in the Project AOI on a localized basis. Air quality is important for health of humans and wildlife. Greenhouse gas (GHG) emissions from the Project may increase the GHG concentrations in the atmosphere.	• Power generation • Other marine vessel and support aircraft combustion sources • Non-routine, temporary flaring • Flaring of pilot gas and periodic maintenance flaring • Fugitive emissions from crude oil storage and offloading • Miscellaneous fuel combustion sources, including incineration, deck cranes, and emergency generators	Ambient offshore air quality data were collected from the vicinity of the Liza Phase 1 Development Project, approximately 30 kilometers (approximately 18 miles) west of the Yellowtail PDA, and included measurements of coarse particulate matter (PM_{10}), carbon monoxide, sulfur dioxide, hydrogen sulfide, nitrogen dioxide, and volatile organic compounds. A similar set of data (with the addition of fine particulate matter [$PM_{2.5}$]) was collected in the vicinity of the Liza Phase 2 PDA, approximately 20 kilometers (12 miles) west of the Yellowtail PDA. A third (similar) set of data was collected in the vicinity of the Payara PDA approximately 45 kilometers (27 miles) northwest of the Yellowtail PDA. Ambient onshore air quality data were also collected at locations in Georgetown and Berbice and included measurements of sulfur dioxide, nitrogen dioxide, carbon monoxide, hydrogen sulfide, $PM_{2.5}$, PM_{10}, and benzene, toluene, ethylbenzene, and xylenes. The collective data sets for offshore and onshore ambient air quality monitoring informed the assessment of potential impacts on air quality by providing information regarding ambient air quality conditions. Project emission inventories have been prepared and air quality dispersion modeling has been conducted to predict potential onshore air quality impacts associated with planned Project activities. Estimated GHG emissions for the Project have been calculated and compared to current national emissions totals for Guyana and global emissions totals from the global oil and gas industry. Project-related GHG emissions were calculated in terms of the Project's proportional contribution to Guyana's total national emissions, and in terms of the quantity of GHGs that Guyana removes from the atmosphere annually (i.e., "net removals").
Sound	Operations on the FPSO and other Project marine vessels will have the potential to result in auditory impacts on Project workers. Underwater sound will have the potential to impact biological receptors (addressed below).	• Equipment/machinery operating on board the FPSO, drill ships, and other marine vessels (relative to potential impacts on Project workers)	The EIA discusses how occupational-related risks within Project-related workspaces will be managed through appropriate design and industrial hygiene and exposure management practices.
Marine Geology and Sediments	The Project will disturb marine geology and sediments on a localized basis in the PDA and could impact sediment quality from deposition of non-aqueous base fluid (NABF) adhered to discharged drill cuttings. Indirect impacts on seismicity and other natural hazards are not expected as a result of the Project.	• Drilling of development wells, including cuttings discharge • Installation of FPSO mooring lines and SURF components	EEPGL has conducted prior sampling of marine sediments in the Stabroek Block as part of iterative environmental baseline study (EBS) events. The collective EBS data set informed the assessment of potential impacts on sediment quality by describing the biophysical attributes of the seafloor. A fate and transport model has been used to simulate cuttings and drilling fluid deposition surrounding the Project development wells. The predicted changes to the native seafloor morphology from the accumulated drill cuttings and other Project-related activities that will impact the seafloor, as well as the distribution of residual NABF on drill cuttings, were described based on the results of the modeling analysis. The EIA describes the reasonably foreseeable effects of oil extraction and injection of water and gas on geological stability, as well as an assessment of the Project's foreseeable impact on geological/seismic hazards (to the extent they may exist).

Resources/Receptors	Potential Impact	Primary Sources of Potential Impacts	Assessment Approach
Marine Water Quality	The Project will have localized impacts on marine water quality in the PDA from discharge of drill cuttings and from routine operational and hydrotesting discharges. The Project also could potentially impact marine water quality in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Drilling of development wells (cuttings and drilling fluid discharge) • Cooling water discharges • Effluent discharges • Produced water discharges • Hydrotesting discharges • Non-routine, unplanned event (i.e., oil spill or release)	EEPGL has conducted prior sampling of marine water quality in the Stabroek Block as part of iterative EBS surveys. The collective EBS data set informed the assessment of potential impacts on marine water quality by supporting the water quality modeling (see below). Fate and transport modeling has been used to evaluate total suspended solids (TSS) concentrations resulting from discharge of cuttings. Modeling has also been used to simulate the mixing zone around the FPSO, and to support an analysis of impacts on marine water quality from routine production operations discharges and one-time hydrotesting discharges. Oil spill modeling has been used to predict fate and transport of oil spills from various unplanned event scenarios (e.g., crude oil spill, diesel fuel spill).
Biological Resources/Receptors			
Protected Areas and Special Status Species	The Project is not expected to impact protected areas as a result of routine, planned activities in the Project AOI. The Project could potentially impact protected areas in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release). The Project could potentially impact some special status species individuals (i.e., listed endangered or threatened species) in the PDA as a result of underwater sound, light, seawater withdrawal, and/or changes in marine water quality. The Project could potentially impact special status species in the Project AOI as a result of non-routine, unplanned events (e.g., oil spill or release, vessel strike).	• Underwater sound generated by marine operations • Lighting on offshore facilities (e.g., FPSO, drill ships) • Seawater intake by FPSO • Effluent discharges • Drilling of development wells (cuttings and drilling fluid discharge) • Cooling water discharges • Produced water discharges • Hydrotesting discharges • Vessel movements • Non-routine, unplanned event (e.g., oil spill or release, vessel strikes with marine mammals or turtles)	As part of an ongoing study initiated prior to scoping for the Project EIA, data on marine fish abundance and distributions have been collected from the Stabroek Block and from areas between the Stabroek Block and shore. The combined data set from these surveys has been incorporated into the EIA to inform the assessment of impacts on special status marine fish species. The study was used to assess whether the fish community in the Project AOI includes any particularly sensitive species, as well as to characterize the distribution of fishery resources relative to the Project AOI. A study initiated prior to scoping for the Project EIA includes tagging and tracking of movements of nesting marine turtles in the Shell Beach Protected Area. Data from this study have been used to supplement existing information on marine turtle movements (and their consequent susceptibility to Project-related impacts). Marine mammal and other protected species observations from EEPGL contractors' offshore vessels have been ongoing since 2015. Findings from these observations have been incorporated into the assessment of impacts on protected marine mammal species and protected fish and turtle species. A study of the presence and distribution of riverine mammals within the lower Demerara River based on visual observations was conducted in 2019 and 2020. The findings of the study informed the assessment of Project vessels' potential impacts on riverine mammals in the Demerara Harbour. Based on a review of the Liza Phase 1 Development Project underwater noise modeling analysis, the attributes of the Yellowtail Development Project subsea noise sources and the environmental features that affect subsea noise propagation (primarily water depths from which the source would emanate) are such that the underwater sound modeling conducted for the Liza Phase 1 Development Project EIA is relevant to the assessment of potential impacts from the Yellowtail Development Project. Accordingly, these results were incorporated into the Yellowtail Development Project EIA by reference and used as the basis for the assessment of potential underwater noise impacts on sensitive species. The Generalized Environmental Modeling System for Surfacewaters (GEMSS) model was used to simulate the mixing zone around the FPSO and to support an analysis of changes to marine water quality from routine operational discharges and one-time hydrotesting discharges (and to assess any associated impacts on special status marine species). A fate and transport model was used to evaluate TSS concentrations resulting from discharge of drilling fluid and cuttings, and to assess associated impacts on special status marine species.

Resources/Receptors	Potential Impact	Primary Sources of Potential Impacts	Assessment Approach
			Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and assess the potential risk of oiling impacting any designated protected areas. Consistent with the approach taken for marine mammals, turtles, and fish without special-status designation, the scientific literature was reviewed for information on the impacts of planned offshore activities on special status species, including marine turtles, marine fish, and marine mammals.
Coastal Habitats	The Project is not expected to impact beaches, mangroves, or wetlands in the Project AOI as a result of routine, planned activities. The Project could potentially impact beaches, mangroves, and wetland habitats in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Non-routine, unplanned event (e.g., oil spill or release)	As part of previous studies, coastal sensitivity maps characterizing coastal habitats within the indirect Project AOI have been developed based on a combination of remote-sensing and field data collection. These maps were used to aid in oil spill response preparation. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and the results of the oil spill modeling were considered together with coastal sensitivity mapping data to assess the risk of oiling beaches, mangroves, or wetlands.
Coastal Wildlife and Shorebirds	The Project is not expected to impact coastal wildlife or shorebirds in the Project AOI as a result of routine, planned activities. The Project could potentially impact coastal wildlife and shorebirds in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Non-routine, unplanned event (e.g., oil spill or release)	As part of a study initiated in 2017, a number of surveys were conducted to characterize coastal bird abundance, diversity, and important habitats along the coastline of Guyana, across different seasons. The combined data set was used to inform the impact assessment for coastal birds. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and the results of the oil spill modeling were considered together with coastal bird data to assess the risk to these receptors from an oil spill or release.
Seabirds	The Project could potentially impact seabirds in a localized manner as a result of light (i.e., disorientation) and other offshore marine operations. The Project could potentially impact seabirds in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Drill ships, FPSO, and support vessel operations • Lighting on offshore facilities (related to potential for disorientation of seabirds) • Non-routine, temporary flaring • Offshore waste incineration • Non-routine, unplanned event (e.g., oil spill or release)	As part of a study initiated in 2017, a number of surveys were conducted to characterize marine bird abundance, diversity, and distributions offshore Guyana, across different seasons. The combined data set was used to inform the impact assessment for marine birds. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and the results of oil spill modeling were considered together with marine bird data to assess the risk to these receptors from an oil spill or release.
Marine Mammals	The Project could potentially impact marine mammals in a localized manner in the Project AOI as a result of Project-related underwater sound, light, and/or changes in marine water quality. The Project could potentially impact marine mammals in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release, vessel strikes).	• Underwater sound generated by marine operations • Changes in forage availability • Lighting on offshore facilities (e.g., FPSO, drill ships) • Effluent discharges • Drilling of development wells (cuttings and fluid discharge) • Cooling water discharges • Produced water discharges • Hydrotesting discharges • Non-routine, unplanned events (i.e., oil spill or release, vessel strikes)	Marine mammal and other protected species observations from EEPGL's offshore study vessels have been ongoing since 2015. Findings from these observations were reviewed together with information from scientific literature to inform the assessment of impacts on marine mammal species by identifying species presence and abundance in the Project AOI. Based on a review of the Liza Phase 1 Development Project underwater noise modeling analysis, the attributes of the Yellowtail Development Project subsea noise sources and the environmental features that affect subsea noise propagation (primarily water depths from which the source would emanate) are such that the underwater sound modeling conducted for the Liza Phase 1 Development Project EIA are relevant to the assessment of potential impacts from the Yellowtail Development Project. Accordingly, these results were incorporated into this EIA by reference, and used as the basis for the assessment of potential underwater noise impacts on marine mammals. The GEMSS model was used to simulate the mixing zone around the FPSO and to support an analysis of changes to marine water quality from routine operational discharges and one-time hydrotesting discharges (and to assess any associated impacts on marine mammals). A fate and transport model was used to evaluate

Resources/Receptors	Potential Impact	Primary Sources of Potential Impacts	Assessment Approach
			TSS concentrations resulting from discharge of drilling fluid and cuttings, and to assess associated impacts on marine mammals. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and the results of oil spill modeling were considered together with the marine mammal data to assess potential spill-related impacts on marine mammals.
Riverine Mammals	The Project is not expected to impact riverine mammals in the Project AOI as a result of routine, planned activities. The Project could potentially impact riverine mammals in the Project AOI as a result of non-routine, unplanned events (i.e., diesel fuel release, vessel strikes).	• Non-routine, unplanned event (e.g., diesel fuel release, vessel strike) • Project-related vessel operations	A study of the presence and distribution of riverine mammals within the lower Demerara River based on visual observations was conducted in 2019 and 2020.The findings of the study informed the assessment of potential disturbance impacts on riverine mammals and potential risks to riverine mammals in the Demerara Harbour from unplanned events (i.e., vessel strikes).
Marine Turtles	The Project could potentially impact marine turtle individuals in a localized manner in the Project AOI as a result of Project-related underwater sound, light, and/or changes in marine water quality. The Project could potentially impact marine turtle individuals in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release, vessel strikes).	• Underwater sound generated by marine operations • Changes in forage availability • Lighting on offshore facilities (e.g., FPSO, drill ships) • Effluent discharges • Drilling of development wells (cuttings and fluid discharge) • Cooling water discharges • Produced water discharges • Hydrotesting discharges • Non-routine, unplanned events (i.e., oil spill or release, vessel strikes)	A study initiated in 2018 includes tagging and tracking of movements of nesting marine turtles in the Shell Beach Protected Area. Data from this study were used to supplement existing information on marine turtle movements (and their consequent susceptibility to Project-related impacts) Based on a review of the Liza Phase 1 Development Project underwater noise modeling analysis, the attributes of the Yellowtail Development Project subsea noise sources and the environmental features that affect subsea noise propagation (primarily water depths from which the source would emanate) are such that the underwater sound modeling conducted for the Liza Phase 1 Development Project EIA is relevant to the assessment of potential impacts from the Yellowtail Development Project. Accordingly, these results were incorporated into this EIA by reference, and used as the basis for the assessment of potential underwater noise impacts on marine turtles. The GEMSS model was used to simulate the mixing zone around the FPSO and to support an analysis of changes to marine water quality from routine operational discharges and one-time hydrotesting discharges (and to assess any associated impacts on marine turtles). A fate and transport model was used to evaluate TSS concentrations resulting from discharge of drilling fluid and cuttings, and to assess associated impacts on marine turtles. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and the results of oil spill modeling were considered together with marine turtle data to assess potential spill-related impacts on marine turtles.
Marine Fish	The Project could potentially impact marine fish as a result of underwater sound, light, changes to seafloor habitat, seawater intake, and changes in marine water quality in the PDA. The Project could potentially impact marine fish in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Underwater sound generated by marine operations • Changes in forage availability • Changes in seafloor habitat • Lighting on offshore facilities (e.g., FPSO, drill ships) • Seawater intake by FPSO • Effluent discharges • Drilling of development wells (cuttings and fluid discharge) • Cooling water discharges • Produced water discharges • Hydrotesting discharges • Non-routine, unplanned events (i.e., oil spill or release)	A study of marine fish abundance, diversity, and distributions in the deepwater, continental shelf and nearshore/estuarine habitat offshore Guyana was conducted from 2017 to 2019. A participatory study of small-scale fishing activity was conducted in 2019 and 2020 to gather additional information, sourced from local fisherfolk, on the abundance and diversity of species caught in fishing areas along the coast. The combined data set from these efforts informed the assessment of impacts on marine fish species by identifying any particularly sensitive species and describing the distribution of fishery resources relative to the Project AOI. The GEMSS model was used to simulate the mixing zone around the FPSO and to support an analysis of changes to marine water quality from routine operational discharges and one-time hydrotesting discharges (and to assess any associated impacts on marine fish). A fate and transport model was used to evaluate TSS concentrations resulting from discharge of drilling fluid and cuttings, and to assess associated impacts on marine fish.

Resources/Receptors	Potential Impact	Primary Sources of Potential Impacts	Assessment Approach
			Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and the results of oil spill modeling were considered together with marine fish data to assess potential spill-related impacts on marine fish.
Marine Benthos	The Project could potentially disturb some benthic habitat and organisms in a localized manner in the PDA.	• Drilling of development wells (cuttings discharge and deposition) • Installation of FPSO (mooring structures) and SURF components • Non-routine, unplanned event (e.g., oil spill or release)	Since 2014, EEPGL has commissioned a series of EBSs, including sediment sampling and analysis of samples for benthos in the eastern Stabroek Block and along the continental shelf between the Stabroek Block and Georgetown. Additionally, as part of the ongoing marine fish study (discussed above), ancillary observations of marine benthos were collected from the Stabroek Block. The combined benthos data set informed the assessment of impacts on marine benthos by characterizing the benthic community and identifying any particularly sensitive species. A fate and transport model was used to predict the extent and thickness of drill cuttings deposition on the seafloor surrounding the development wells. These data were considered in combination with the above information to assess impacts on marine benthos as a result of drill cuttings deposition.
Ecological Balance and Ecosystems	The Project could have indirect impacts on ecological functions in the Project AOI, particularly if special status species or trophic relationships are disturbed.	• Underwater sound generated by marine operations • Lighting on offshore facilities (e.g., FPSO, drill ships) • Seawater intake by FPSO • Installation of FPSO and SURF components • Effluent discharges • Ballast water discharges • Offshore waste incineration • Non-routine, unplanned event (e.g., oil spill or release)	An environmental deoxyribonucleic acid (DNA) study was conducted in 2016 and 2017. This study provided information on the number of species present in the AOI based on remnant DNA in the water column from naturally shed tissue fragments. The plankton component of the 2017–2019 fish survey provided additional information on the plankton component of the marine community within the AOI. The results of these studies were used to enhance the understanding of biodiversity in the AOI. The data from these studies and from field studies of other taxon groups (see above) were considered together with scientific literature to assess impacts on the ecosystem as a whole. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and the results of oil spill modeling will be considered together with the above data to assess potential spill-related impacts on the ecosystem as a whole.
Socioeconomic Resources			
Socioeconomic Conditions	The Project is generally anticipated to have a positive impact on the economy of Guyana as a result of government revenue sharing from the Project, as well as employment and local procurement opportunities. Potential adverse impacts may include potential short-term increases in the cost of living as a result of increased demand for specific goods and services. Potential adverse impacts on income from agriculture and fisheries could also occur as a result of non-routine, unplanned events (i.e., oil spill or release).	• Government revenue sharing from Project • Local Project purchases of select materials, goods and services • Limited local Project employment (direct and indirect) • Increased spending on select materials, goods and services (indirect multiplier impacts for local/regional population)	Government reports were reviewed and key informant interviews were conducted to identify key economic drivers in the national, regional, and local economies and assess the likely Project-related effects on these economic factors. Particular emphasis was placed on livelihoods that are important to coastal communities.
Employment and Livelihoods	The Project is expected to build capacity in the local labor force, increase demand for skilled labor, and increase demand for service industries. There is the potential for limited adverse impacts on fishing activities (and livelihoods stemming from those activities) as a result of marine safety exclusion zones or marine traffic, and non-routine, unplanned events (i.e., oil spill or release).	• Local employment for Project-related activities • Marine safety exclusion zones • Project-related marine traffic • Project operations (aspects relating to occupational health and safety for Project workforce) • Non-routine, unplanned event (e.g., spill or release)	Project workforce projections and types of labor requirements were assessed against data obtained through key informant interviews on the existing service industry within Guyana. The potential for adverse impacts on fishing activities was assessed by taking into consideration the distance from shore at which different fishery types typically operate, in comparison to the locations and durations of Project-related marine activity and marine safety exclusion zones. The 2019–2020 participatory fishing study provided additional information, sourced from local fisherfolk, on local fishing activities and catch quantities at key fish landing sites. The collective body of information from these data collection efforts was used to assess potential socioeconomic impacts on fisherfolk in the AOI. The EIA discusses that occupational-related risks will be managed through appropriate design and industrial hygiene and exposure management practices.

Resources/Receptors	Potential Impact	Primary Sources of Potential Impacts	Assessment Approach
Community Health and Wellbeing	Most Project activities will be located offshore and will have no direct impacts on communities in Guyana. Project-related increases in vehicular and marine traffic could increase the potential for accidents. Introduction of limited levels of foreign labor for the Project workforce could potentially have community health impacts due to an increased risk of communicable diseases. The Project workforce could result in an increased use of medical and health resources in the Georgetown area, resulting in the potential to overburden those resources. The overall presence of the Project and other related activities as a new industry in the country could lead to a level of public anxiety. Non-routine unplanned events (i.e., oil spill or release) could impact health and wellbeing of communities via impacts on resources on which these communities depend.	• Increased vehicular and marine traffic as a result of Project activities (related to increased potential for accidents) • Social interaction between foreign Project workers and residents, in particular with respect to an increased risk of transmission of communicable diseases • Public anxiety from perceptions of risk from a relatively new type of industry in the country • Non-routine, unplanned event (e.g., oil spill or release)	Data on existing marine traffic and vehicular traffic collected in 2018 were used to assess potential risks to safety and health of local communities posed by Project-related increases in marine and vehicular traffic (as relates to potential unplanned events in the form of accidents). Key informant interviews were conducted to assess existing medical and health infrastructure and were used to assess the risk of the Project overburdening these resources. Stakeholder interviews were also used to help assess impacts related to public anxiety over oil and gas operations. The uses of natural resources by local coastal communities were mapped to identify specific dependencies on resources that could be impacted by an unplanned event (i.e., oil spill). These data were used to assess potential Project impacts on the quality or accessibility of these services. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and to assess potential spill-related impacts on community health and wellbeing.
Marine Use and Transportation	The Project activities will result in increased marine-related traffic, which could potentially contribute to marine vessel congestion in port areas, as well as increasing the risk of unplanned events (i.e., marine vessel collisions).	• Project-related marine vessel operations	Key informant interviews were conducted to characterize communities dependent on marine transportation and use for livelihoods (e.g., speedboat operators and fisherfolk), and to characterize existing marine vessel operations in the Project AOI. This information was supplemented with the primary data previously collected via observations made in 2018 of marine vessel traffic operating between the Guyana shorebases and the mouth of the Demerara River. These data were considered in conjunction with estimates of anticipated Project-related traffic and marine use to assess the incremental change in demand on the port's and harbor's capacities to accommodate foreseeable marine use and transportation demands. The EIA also includes a discussion of tanker activities anticipated as a result of the Project, as well as the key operational procedures and controls (both within and outside of Guyanese waters) that will be implemented in relation to these activities.
Social Infrastructure and Services	The Project will increase use of public infrastructure and services and thus could potentially compete with other existing businesses and consumers across a range of services (e.g., roads, airports/helicopters, accommodations, and utilities). The Project will result in increased vehicular traffic in Georgetown, which could potentially contribute to vehicular congestion in certain areas.	• Project demand requirements for lodging, housing, and utilities, which could increase the burden on existing capacity and supply • Shorebase operations and other Project-related onshore transportation of materials and personnel, which could contribute to traffic congestion • Project-related use of helicopters and airports	Key informant interviews, reviews of publicly available government reports, and results from a social infrastructure study focused on Project-related use of Georgetown lodging and housing were used to assess existing demand on these resources and the potential impact that additional Project-related demand on these resources could have on affected communities. Existing vehicular traffic conditions were characterized through the prior traffic study conducted in the vicinity of the Guyana shorebases and an additional traffic study conducted for other Georgetown road segments. Information from these studies was considered together with estimates of Project-related onshore traffic to assess the impact of Project-related vehicle movements on local traffic conditions. Estimates of Project-related helicopter/airport use were used to assess the impacts on availability of helicopters for other industrial purposes.
Waste Management Infrastructure and Capacity	The Project will increase the demand for hazardous and non-hazardous waste management services and infrastructure in Guyana and thus could potentially compete with other existing waste generators for limited waste management capacity.	• Project demand requirements for hazardous and non-hazardous transportation, treatment, and disposal services, which could increase the burden on existing capacity and supply	Government reports were reviewed and key informant interviews were conducted to establish current waste management capacity and plan for future expansions. These data were compared to EEPGL's projections of waste production over the life of the Project to determine the proportion of anticipated waste management capacity that would be consumed by the Project.
Cultural Heritage	The Project has the potential to adversely affect cultural heritage through localized disturbance of any archaeological or historic resources present in the subsea Project footprint. Such resources could have conservation, cultural, and other values to stakeholders. The Project also could potentially impact cultural heritage resources	• Drilling of development wells • Installation of FPSO and SURF components • Non-routine, unplanned event (i.e., oil spill or release)	EEPGL has completed a geophysical and shallow geotechnical analysis that assessed the layout and field architecture for the PDA to aid in siting facilities away from faults, seabed obstructions, archaeological resources, sensitive biological resources, or other resources or hazards that could either damage the wells or SURF or be damaged by installation of these components. Autonomous

Resources/Receptors	Potential Impact	Primary Sources of Potential Impacts	Assessment Approach
	outside of the subsea Project footprint as a result of non-routine, unplanned events (i.e., oil spill or release).		underwater vehicles and other geophysical surveys were used to assess for the presence of manmade objects on the seabed within the PDA. Coastal communities in the Project AOI, including indigenous communities, were engaged from 2017–2019 to characterize areas along the coast with cultural heritage significance. As part of this effort, key informant interviews were conducted and Traditional Cultural Knowledge was leveraged. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill and to assess the potential for a release from an unplanned event to contact identified terrestrial cultural heritage sites.
Land Use	No new Project-dedicated land disturbance is planned. There is the potential that third-party onshore facilities may elect to expand or impact adjacent land as a result of supporting Project-related needs; however, these impacts are outside the scope of this EIA.	• Shorebase operations • Pipe yards • Warehouses • Bulk fuel storage and transfers • Onshore waste recycling, treatment and disposal facilities	Land use in the area surrounding onshore facilities planned for Project use was reviewed and assessed with respect to the potential for impacts on land use as a result of the Project.
Ecosystem Services	Project-related impacts on natural resources could lead to short-term direct or indirect impacts on the services and/or values derived from natural resources and ecosystems in the Project AOI.	• Direct or indirect impacts derived from one or more of the impacts on physical, biological, or socioeconomic resources described above	The uses of natural resources by local coastal communities, including indigenous communities, were mapped in 2017–2019 to identify specific dependencies on resources that could be impacted by the Project. Data from this effort, including Traditional Cultural Knowledge, were used to aid in assessing dependencies on natural resources that could be impacted by the Project in terms of local communities' access to and use of impacted resources. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill from the Project and to assess the potential for oil to contact areas providing ecosystem services.
Indigenous Peoples	The Project is not expected to directly cause any changes to population or demographics in indigenous communities. The Project could potentially impact Indigenous Peoples in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Non-routine, unplanned event (i.e., oil spill or release)	Coastal communities, including indigenous communities, in the Project AOI were engaged to characterize coastal biodiversity and ecosystem services. As part of this effort, key informant interviews were conducted and Traditional Cultural Knowledge leveraged to characterize socioeconomic conditions in communities, and their reliance on natural resources. Oil spill modeling was used to simulate the trajectory of a hypothetical oil spill from the Project and, based on information collected from the above study, to assess the potential for oil to contact lands and natural resources of coastal indigenous communities.

$PM_{2.5}$= particulate matter with aerodynamic diameter of less than 2.5 micrometers; PM_{10} = particulate matter with aerodynamic diameter of less than 10 micrometers

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Table 5.2-2: Resources and Receptors Excluded from Further Consideration in the EIA

Resource/Receptor	Rationale for Excluding
Coastal (Onshore) Resources	
Onshore geology/soils	The Project will not result in any onshore disturbance to geology and soils.
Topography/landscape	The Project will not require any excavation, fill, or other land-based activities that could change onshore topography or landscapes.
Groundwater	The Project will not involve any activities that could impact ground water quantity or quality.
Terrestrial vegetation	The Project will not require any clearing or disturbance of terrestrial vegetation. Even in the case of an unplanned event such as a spill, only estuarine vegetation (e.g., mangroves) would be expected to be potentially impacted (this is addressed under the coastal habitat resource).
Freshwater habitats	The Project is offshore, with no new onshore disturbance, so will not have any impact on freshwater habitats.
Marine Resources	
Aquatic plants	The marine aspects of the Project will occur in an area that is too deep to support vascular marine plants.
Physical Resources	
Vibration and radiation	The Project will not generate any vibration or radiation that is expected to impact resources/receptors. See Section 2.13, Materials, Emissions, Discharges, and Wastes, for a description of radiation sources that will be used by the Project, and the related procedures that will be employed to ensure protection of Project workers.
Socioeconomic Resources	
Security and human rights	Due to its distance from communities, the Project will not affect security concerns within Guyana. The Project will also not require any resettlement, affect any access to vital resources, or affect existing legal protections afforded to Guyanese under law, so this issue is therefore not carried forward for analysis.

5.2.1. Assessment of Potential for Geological/Seismic Impacts

During the scoping processes for previous EIAs for EEPGL's offshore developments as well as the Yellowtail Development Project's scoping process, the public indicated concern that offshore development activities could potentially result in a seismic event and—as a result of such an event—inland flooding (e.g., from a tsunami). Based on consideration of the potential for Project activities to result in these types of events, the Consultants determined it was appropriate to exclude this potential impact from further consideration in the EIA. However, in light of the public's stated concerns, the following discussion is presented to elaborate on the justification for this exclusion.

5.2.1.1. Natural Disaster Risk Ratings for Guyana

In 2014, the United Nations International Strategy for Disaster Reduction (UNISDR) assessed natural hazard risk in Guyana as part of a global initiative to assess vulnerability to natural disasters. UNISDR's disaster risk profile for Guyana indicates that based on historical records, floods, droughts, and landslides pose the most significant risks to Guyana (UNISDR 2014). This assessment was based on a "look back" at the incidence of natural hazards that have occurred in the past, but did not indicate probability of hazards occurring in the future. However, the UNISDR also conducted a probabilistic assessment that used mathematical models to combine possible future hazard scenarios, information about exposed assets, and potential vulnerability to provide estimates of probable economic losses due to different categories of disasters. Unlike the "look back" assessment, the probabilistic risk assessment addressed the limitations associated with deriving risk from historical disaster loss data by accounting for all types of disasters that can occur in the future, including higher-intensity losses with long recurrence intervals (UNISDR 2014). This assessment indicated that floods pose, by far, the most significant risk to Guyana, followed by relatively minor risks from earthquakes. The risks posed by tsunamis were determined to be not significant enough to be reported in the economic analysis. The assessment indicated that the predicted recurrence interval of a tsunami in Guyana exceeded 1,500 years (UNISDR 2014).

Additionally, the World Bank Group's *ThinkHazard!* tool, an online, natural hazard risk database for emerging market countries, was queried to assess relative risk ratings for a suite of potential natural hazards for Guyana. The results of the assessment are generally consistent with the UNISDR assessment, ranking floods as high risk, tsunamis as medium risk, and earthquakes as very low risk for Guyana (World Bank 2019).

Additional information regarding earthquake and tsunami risks to Guyana is presented below.

5.2.1.2. Assessment of Earthquake Risks to Guyana

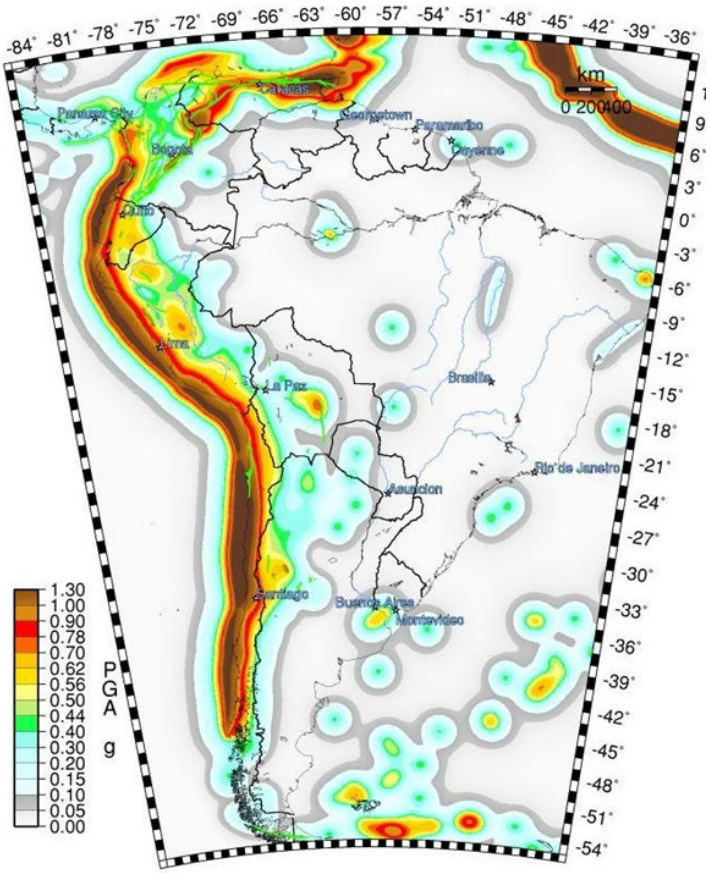
Seismic hazard refers to the risk associated with the potential occurrence of earthquakes in a particular area. Guyana is located within the craton[1] of the South American tectonic plate. Seismicity in the northern part of the continent of South America is largely controlled by plate boundary events occurring along the southern rim of the Caribbean Basin. Major earthquakes frequently occur along the Lesser Antilles subduction zone, where the South American Plate is subducting beneath the Caribbean Plate. The Yellowtail PDA is located more than 280 kilometers (174 miles) from the boundary between the Caribbean and South American plates and more than 1,050 kilometers (652 miles) from the nearest area of active seismicity (in the vicinity of Puerto Rico).

[1] The stable interior portion of a continent characteristically composed of ancient crystalline basement rock

A seismic hazard map shows the relative seismic hazards in different areas. These maps are typically developed using information known about:

1. Past faults and earthquakes;
2. The behavior of seismic waves as they travel through different materials of the Earth's crust; and
3. The near-surface site conditions at specific locations of interest.

The U.S. Geological Survey (USGS) Hazard Mapping Program produces probabilistic seismic hazard maps that show the potential for ground motion, as measured by what is known as *peak ground acceleration*, which is expressed as a multiple of the acceleration of gravity (g), e.g., *0.1g,* meaning one-tenth the acceleration of gravity. Ground acceleration is the velocity of a particle on the ground that is recorded by a particular station during an earthquake and can be considered to reflect what a person might feel standing on the ground in an earthquake. Figure 5.2-1 shows the USGS's preliminary peak horizontal ground acceleration seismic hazard map for South America (USGS 2010). The map presents the peak ground accelerations with a 2 percent probability of being exceeded in a 50-year return period. As shown in the figure, the peak ground acceleration with a 2 percent probability of exceedance over a 50-year return period in the vicinity of the Yellowtail PDA is between 0.00g and 0.05g. To put this into perspective, 0.001g is generally perceptible by people, 0.02g is the point where a person would typically lose their balance, and 0.5g results in severe shaking, with moderate damage to buildings. Therefore, this indicates that there is a 2 percent chance in a given 50-year period that a very small seismic event (which might not even be perceptible if someone were at the exact location of the event) would occur in the PDA. Referring to the map, the nearest area identified on the map as having an elevated seismic risk is approximately 320 kilometers [approximately 174 miles] away from the Yellowtail PDA, at the boundary between the Caribbean and South American plates.



Source: USGS 2010

Note: Hazard map shows the peak ground acceleration with a 2 percent probability of being exceeded in a 50-year return period.

Figure 5.2-1: Preliminary Seismic Hazard Map for South America

5.2.1.3. Assessment of Tsunami Risks to Guyana

Guyana could experience tsunamis generated from seismic activity outside Guyana if such activity propagated waves of sufficient magnitude and in the required direction. Most of the available research on seismic risk in the region has focused on three potential locations where seismic activity could originate (see Figure 5.2-2):

- The Septentrional-Oriente Fault Zone, north of the Dominican Republic;
- The Hispaniola Trench, north of the Dominican Republic; and
- The Puerto Rico Trench, which begins off the northeast coast of Hispaniola and extends along a generally east-west axis for more than 750 kilometers (approximately 466 miles) into the western Atlantic Ocean.

Source: WHOI 2005

Figure 5.2-2: Areas of Potential Seismic Risk

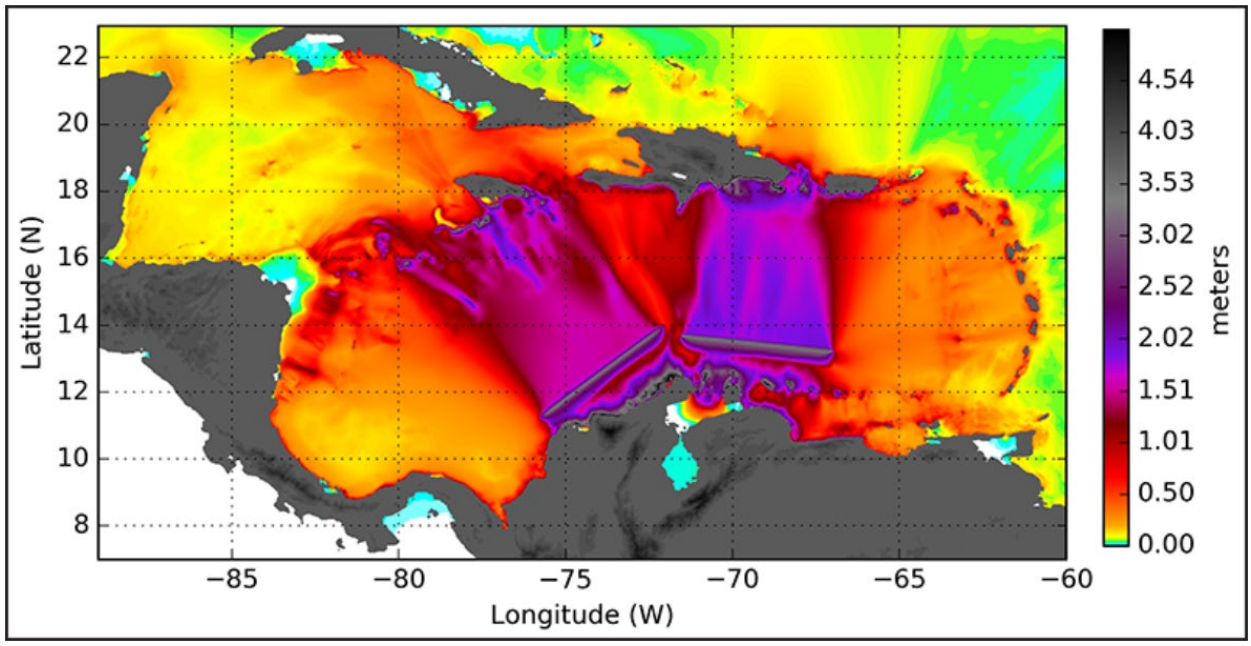
In 2005, the Woods Hole Oceanographic Institute reported that although all three of these features are capable of producing earthquakes large enough to induce tsunamis, the overall risk of such an event is small, and the greatest risk associated with earthquake-generated tsunamis in these locations would be to Hispaniola and Puerto Rico (WHOI 2005; Brink and Lin 2004).

In light of recent seismic events around the globe, such as the 2010 earthquake and tsunami in Haiti, ICG/CARIBE-EWS[2] established a permanent working group (WG2) with specific focus on the potential impacts of tsunamis across Caribbean communities, so that emergency planners can pursue risk mitigation and preparedness. To assess tsunami potential, WG2 conducted numerical simulations of 17 seismic sources associated with the Caribbean Plate and affecting

[2] Intergovernmental Coordination Group of the Early Warning System for Tsunamis and Other Coastal Threats for the Caribbean Sea and Adjacent Regions

northern Hispaniola, Honduras, southern Dominican Republic, and Central America using the numerical model Tsunami-HySEA (Macías et al. 2017). Figure 5.2-3 illustrates results from this exercise, showing the regions concluded to be at risk in terms of maximum wave height for the largest possible event in the list of 17 scenarios studied by WG2: a hypothetical Mw[3] 8.9 earthquake that simultaneously ruptures two faults, each 500 kilometers (310.7 miles) long, near the coast of South America at the Southern Caribbean Deformed Belt.

The WG2 work indicated that in the unlikely event of a tsunami generated at the Septentrional Fault Zone or the Hispaniola Trench, the risk to Guyana would be essentially zero because the land masses of Hispaniola, Puerto Rico, and the Lesser Antilles would shield Guyana from any tsunami that propagated in a southerly direction (López-Venegas et al. 2018) (Figure 5.2-3). The same would be true of seismic activity along the western portion of the Puerto Rico Trench. Guyana could theoretically be exposed to a tsunami that arose at the extreme eastern end of the Puerto Rico Trench and propagated southward; however, the Puerto Rico Trench is located approximately 1,050 kilometers (approximately 652 miles) away from the Yellowtail PDA.



López-Venegas et al. 2018

Figure 5.2-3: Areas of Potential Tsunami Risk

Natural processes that modulate the spatial and temporal occurrence of earthquakes include tectonic stress changes, migration of fluids in the crust, Earth tides, surface loading and unloading, heavy precipitation, atmospheric pressure changes, and groundwater loss (Kundu et al. 2015). In rare cases, human-related activities may supplement natural tectonic processes and trigger earthquakes (Foulger et al. 2018). For oil and gas operations, these activities include

[3] Moment magnitude, which is based on the concept of seismic moment, is a measure of the size of an earthquake based on the area of fault rupture, the average amount of slip, and the force required to overcome the friction sticking the rocks together that were offset by faulting.

injection, production, and stimulation. In all cases, the presence of critically stressed planes of weakness (e.g., faults) is required to host and accommodate seismic slip (Alt and Zoback 2016).

There are no mapped faults in the Yellowtail PDA, but a recent geophysical study mapped several small faults along the edge of the continental shelf south of the Yellowtail PDA. These faults have been interpreted as surficial defects created by steepening of the continental shelf edge. Evidence of past landslide activity immediately north of the continental shelf edge indicates a process of slumping at the shelf margin leading to submarine landslides transporting material off the shelf and into deeper water (Guardian Geomatics 2020). These past mass transport events further steepen the shelf edge, leading to cracking/faulting at the northern margin of the shelf and another cycle of slumping and landslides. Numerous sediment fans indicative of past mass transport events extend northward from the continental shelf in the southern portion of the geophysical survey area. These features provide evidence of past downslope movements from the edge of the continental shelf into deeper water, but the largest of these features are overlain by smaller more recent depositional fields, indicating that the cycle of faulting, sliding, and re-steepening at the shelf margin is either slowing or is no longer active (Guardian Geomatics 2020). Regardless of whether this process is still occurring, the Yellowtail PDA is located north of continental shelf edge and outside the depositional zone from past landslides. Consequently, the likelihood of the Project either affecting the incidence of future submarine landslides or being affected by them is considered extremely low.

5.2.1.4. Conclusion

The Project is considered to have a negligible potential to result in seismic risk, including risk of tsunamis reaching Guyana, for the following reasons:

- Guyana has a low risk of exposure to seismic risks in general.
- Guyana would be naturally buffered from the effects of a tsunami originating at most of the known seismically active zones in the region, even in the extremely unlikely event that such an event occurred.
- The Project's drilling activities would not have a reasonable potential to affect seismic stability at the areas identified in the region as active seismic areas (the nearest being approximately 280 kilometers [approximately 174 miles] away from the PDA).
- There are no mapped faults in the Yellowtail PDA, and, consequently, the likelihood of seismic slip that could be caused by injection, production, and stimulation of the reservoir in the PDA is anticipated to be extremely low.
- The Project is located outside the mapped area of influence of historical submarine landslides.

Accordingly, potential seismic impacts have been scoped out of further assessment in the EIA.

5.2.2. Assessment of Potential for Acoustic Impacts from Vessel Noise in Georgetown Harbour

During the scoping process for the EIA, the EPA indicated a concern that noise from Project vessels ingressing or egressing Georgetown Harbour could potentially impact sensitive receptors along the banks of the Demerara River. The Consultants conducted a screening-level analysis to determine whether this potential impact was appropriate to include for detailed analysis in the EIA. Potential human exposure to sound from vessels transiting the Demerara Harbour was evaluated based on the types of vessels that are expected to transit the area between the mouth of the river and the shorebases that may be used to support vessel traffic. This analysis relied on literature-based proxy values for sound generated by sea-going vessels and literature-based sound attenuation rates over water. Given the homogenous nature of riparian land use adjacent to Georgetown Harbour, sound exposure at the shoreline was calculated based on a vessel's anticipated minimum distance from shore rather than modeled for specific sensitive receptors.

Marine vessels transiting through Georgetown Harbour would generate temporary noise as they pass through the harbor. Limited data are available for overwater noise generated by marine vessels as the bulk of the noise impacts associated with marine vessel operation occurs underwater. A literature review was completed to identify sound levels available for marine vessels similar to the drill ships and support vessels proposed to be used for the Project, resulting in the selection of acoustic data for engine exhaust and ventilation systems on ocean-going cargo vessels (Badino et al. 2016). These data were used as proxies for the sound profile associated with drill ships and support vessels transiting Georgetown Harbour. Because the Project vessels would be transiting through the harbor and not operating deck- or exterior-mounted heavy machinery (e.g., cranes, winches, drills) while in transit, other ship operations that may generate noise, such as drilling, were not considered in the analysis.

Table 5.2-3 presents the estimated overwater noise associated with drilling ship engine operation and the resulting estimated noise contribution from engine operation at the noise-sensitive area nearest the main shipping channel within the harbor, which was determined to be the residential portion of Vreed-en-Hoop. Vessels would pass approximately 300 meters (984.3 feet) from this area.

Table 5.2-3: Noise Associated with Marine Vessel Operations

Vessel Equipment	Sound Power Level (dBA)	Noise Contribution of Vessel Operation at 300 Meters (L_{eq} dBA)	Noise Contribution of Vessel Operation at 300 Meters (L_{dn} dBA)
Engine Exhaust and Ventilation	87.3	27.6	34.0

Source: Badino et al. 2016

dBA = A-weighted decibels; L_{eq} = equivalent sound level; L_{dn} = day-night sound level

As shown in Table 5.2-3, the estimated day-night sound level (L_{dn}) associated with vessel operation at the nearest noise sensitive receptor (i.e.; the residential district of Vreed-en-Hoop) would be 34.0 A-weighted decibels (dBA). Published estimates of sound levels in developed urban areas range from 50 to 65 dBA L_{dn} (ANSI 2013). Based on these estimated background sound levels, the operation of marine vessels would likely be audible when passing, but would not be the dominant noise source at noise-sensitive locations in proximity to the transiting vessels. Noise from vessel operations would also be significantly lower than the 75 dB/60 dBA day/night noise guidelines recently adopted by the EPA.

Noise from vessel operations would also be significantly lower than 55 dBA Ldn, which the U.S. Environmental Protection Agency (USEPA) considered protective of residential uses (including sleep disturbance and annoyance) and 45 dBA Leq, which is the most protective nighttime noise level recommended by the International Finance Corporation (IFC) for residential, institutional, and educational uses. Decibels are calculated on a logarithmic scale and the predicted Project noise levels in Table 5.2-3 are more than 10 dBA lower than the USEPA and IFC noise level recommendations, meaning that the predicted noise levels are less than half the applicable thresholds recommended by the USEPA and IFC. Therefore, noise levels associated with vessel traffic are not anticipated to lead to annoyance or sleep disturbance or long-term / irreversible detrimental effects.

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6. ASSESSMENT AND MITIGATION OF POTENTIAL IMPACTS FROM PLANNED ACTIVITIES—PHYSICAL RESOURCES

For the purposes of this EIA, physical resources include non-biological natural resources. The physical resources existing conditions discussions presented herein are based on a combination of primary data generated from EEPGL-commissioned studies and secondary data from peer-reviewed scientific literature. Specifically, the information presented for air quality and climate, marine geology and sediments, and marine water quality was generated from EEPGL-commissioned studies and supplemented by scientific literature and Government of Guyana data. The information presented for sound was derived from scientific literature.

6.1. AIR QUALITY, CLIMATE, AND CLIMATE CHANGE

6.1.1. Administrative Framework—Air Quality, Climate, and Climate Change

Table 6.1-1 summarizes the legislation, policies, or treaty commitments that focus specifically on air quality, climate, and climate change.

Table 6.1-1: Legislation, Policies, or Treaty Commitments—Air Quality, Climate, and Climate Change

Title	Objective	Relevance to the Project
Legislation		
Environmental Protection Air Quality Regulations, 2000	Requires environmental authorisation for industrial facilities emitting air contaminants. Establishes that the EPA shall at any time after the commencement of the Regulations, establish limits for any of the contaminants specified in the regulation.	Applicable to Project sources of emissions to air (although no limits have yet been established by the EPA).
International Agreements Signed/Acceded by Guyana		
Paris Agreement (under the United Nations Framework Convention on Climate Change [UNFCCC])	Promotes international cooperation to limit average temperature increases and resulting changes in climate, and international cooperation to adapt to these impacts.	Provides a framework for possible future regulation of greenhouse gas (GHG) emissions within Guyana's territory (maritime and land) and for establishing national policy regarding adaptation to climate change.
Vienna Convention on the Protection of the Ozone Layer (Guyana acceded in 1993)	Provides a framework for the protection of the ozone layer.	Establishes measures for protecting the ozone layer.

Title	Objective	Relevance to the Project
Montreal Protocol on Substances that Deplete the Ozone Layer (Guyana acceded in 1993)	A protocol to the Vienna Convention designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion.	Prohibits the use of several groups of halogenated hydrocarbons that may deplete the ozone layer.

In addition to regulations and international conventions, ambient air quality guidelines are specific concentration levels in air that are established to protect human health in locations where exposure can potentially occur. These generally include a margin of safety to ensure that individuals with a higher sensitivity to air pollutants are also protected. As noted above, the EPA has not established specific ambient air quality standards for Guyana; therefore, the guidelines used for reference in this assessment are those established by the World Health Organization (WHO) and the U.S. Environmental Protection Agency (USEPA). WHO guidelines can be found in the WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide—Global Update 2005 (WHO 2005) and the more recent WHO Global Air Quality Guidelines (WHO 2021), except for carbon monoxide (CO), hydrogen sulfide (H_2S), and toluene, for which WHO guidelines were published in the WHO Air Quality Guidelines for Europe, 2nd edition (WHO 2000). The USEPA National Ambient Air Quality Standards (NAAQS) are summarized in USEPA 2021. The ambient air quality guidelines considered for assessment of existing conditions and the impact assessment are summarized in Table 6.1-2.

Table 6.1-2: Ambient Air Quality Guidelines Considered in the Assessment

Pollutant	Averaging Period	Guideline Concentration (µg/m^3 except as noted)			
		WHO 2000	WHO 2005	WHO 2021	USEPA 2021
NO_2	1-hour[j]	-	200		-
	1-hour (98th percentile) [a]	-	-		188 (100 ppb)
	24-hour (99th percentile)[b]	-		25	-
	Annual [f]	-		10	100 (53 ppb)
SO_2	10-minute[h]	-	500		-
	1-hour (99th percentile)[c]	-	-		196 (75 ppb)
	24-hour (99th percentile)[b]	-		40	-
PM_{10}	24-hour (99th percentile)[b]	-		45	-
	24-hour (second high)[g]	-	-		150
	Annual [f]	-		15	-
$PM_{2.5}$	24-hour (99th percentile)[b]	-		15	-
	24-hour (98th percentile)[d]	-	-		35
	Annual	-		5[f]	12[e]

Pollutant	Averaging Period	Guideline Concentration (µg/m³ except as noted)			
		WHO 2000	WHO 2005	WHO 2021	USEPA 2021
CO	15-minute[i]	-	100,000		-
	1-hour	-	35,000[j]	-	40,000 (35 ppm)[l]
	8-hour	-	10,000[k]	-	10,000 (9 ppm)[m]
	24-hour (99th percentile)[b]	-	-	4,000	-
H_2S	24-hour[n]	150	-	-	-
Toluene	1-week	260	-	-	-
Benzene	24-hour	-	-	-	30 (9.4 ppb)
Ethylbenzene	Annual	-	-	-	1.0 (0.23 ppb)
Xylene	24-hour	-	-	-	434 (100 ppb)

µg/m³ = micrograms per cubic meter; NO_2 = nitrogen dioxide; PM_{10} = particulate matter (aerodynamic diameter less than 10 microns); $PM_{2.5}$ = particulate matter (aerodynamic diameter less than 2.5 microns); ppb: parts per billion; ppm: parts per million; SO_2 = sulfur dioxide
[a] Average of the 98th percentile 1-hour average concentrations for each of the modeled years.
[b] Maximum of the 99th percentile 24-hour average concentrations across all modeled years.
[c] Average of the 99th percentile 1-hour average concentrations for each of the modeled years.
[d] Average of the 98th percentile 24-hour average concentrations for each of the modeled years.
[e] Average of the annual average concentrations for each of the modeled years.
[f] Maximum of the annual average concentrations across all modeled years.
[g] Maximum of the second-highest 24-hour average concentrations across all modeled years.
[h] Maximum of the 10-minute average concentrations across all modeled years.
[i] Maximum of the 15-minute average concentrations across all modeled years.
[j] Maximum of the 1-hour average concentrations across all modeled years.
[k] Maximum of the 8-hour average concentrations across all modeled years.
[l] Maximum of the second-highest 1-hour average concentrations across all modeled years.
[m] Maximum of the second-highest 8-hour average concentrations across all modeled years.
[n] Maximum of the 24-hour average concentrations across all modeled years.

The guidelines shown in Table 6.1-2 were used to assess the existing conditions of the ambient airshed (i.e., undegraded vs. degraded) based on measured concentrations, and the significance of potential impacts on air quality as predicted by air quality dispersion modeling. The WHO 2000 and WHO 2005 guidelines do not specify a "ranking" for values to be compared to short-term (10-minute to 8-hour) guidelines (e.g., the highest value, the second highest value, etc.); accordingly, the maximum observed or modeled concentration is used for comparison to WHO 2000 and WHO 2005 guidelines. Modeling for 1-hour standards involves predicting concentrations for every hour of the year; this means that out of 8,760 concentration predictions per modeled year, the single highest value is used for comparison to a WHO 2005 1-hour guideline. By contrast, the WHO 2021 and USEPA NAAQS guidelines employ a statistically based metric for comparison to some guidelines (e.g., the 98th percentile value for 1-hour nitrogen dioxide (NO_2); the 99th percentile value for 24-hour NO_2; the 99th percentile value for 1-hour SO_2 [sulfur dioxide]). For the air quality modeling presented herein, the WHO 2005 guideline and the USEPA NAAQS guideline for 1-hour NO_2 are both used for comparison purposes; the USEPA NAAQS guideline provide a more robust comparison that does not assess the single highest hourly value, while the WHO 2005 guideline considers the single highest hourly value—effectively representing an extreme upper bound estimate. Similarly, the WHO guideline and the USEPA NAAQS guideline for 24-hour PM_{10} and $PM_{2.5}$ are both used for comparison purposes. For each pollutant and averaging time, if more than one guideline for a

given averaging period is listed in the table above (e.g., annual average $PM_{2.5}$), the lowest was used in the assessment.

6.1.2. Existing Conditions—Air Quality, Climate, and Climate Change

This section describes the existing air quality conditions and climate in the Project Area of Influence (AOI). Additionally, the section provides a discussion of the current scientific understanding of the potential consequences of global climate change.

Air quality in a geographic area is determined by the presence of background concentrations due to natural and distant sources, the type and amount of pollutants emitted locally into the atmosphere, the topography of the area, and the weather and climate conditions in the area. The levels of pollutants and pollutant concentrations in the atmosphere are typically expressed in units of parts per million (ppm), parts per billion (ppb), or micrograms per cubic meter ($\mu g/m^3$) averaged over various periods of time (e.g., 1-hour average, 24-hour average).

6.1.2.1. Existing Conditions—Air Quality

This section describes the existing ambient air quality conditions in the Project AOI. Existing air quality conditions are described for both the offshore environment in the Stabroek Block and the onshore environment, the latter representing the area where community receptors could potentially be impacted by emissions to air from the Project.

Existing Conditions—Offshore Air Quality

The Project Development Area (PDA) is located approximately 203 kilometers (approximately 126 miles) northeast of the coastline of Georgetown in the Atlantic Ocean, far removed from any anthropogenic sources of emissions other than intermittent marine traffic and oil and gas exploration and development activities. Therefore, offshore ambient air quality in the PDA is determined primarily by regional influences rather than by local emission sources or topographic influences. Additionally, the prevalent wind direction is from the east-northeast (i.e., from the open ocean); therefore, ambient air quality within the PDA is expected to be undegraded. Nevertheless, to characterize existing offshore air quality conditions in the vicinity of the PDA, the Consultants drew from four offshore ambient air monitoring campaigns completed in the Stabroek Block:

- From 3 October through 23 October 2016, air quality monitoring equipment was deployed on a research vessel and samples were collected within the Stabroek Block in the vicinity of the Liza Phase 1 PDA. Pollutants sampled included inhalable particulate matter (PM) (i.e., that fraction with aerodynamic diameter of less than 10 micrometers [PM_{10}]), CO, sulfur dioxide (SO_2), H_2S, NO_2, total non-methane volatile organic compounds (VOCs), and selected speciated VOCs.
- From 9 April through 16 April 2018, air quality monitoring equipment was deployed on a research vessel and samples were collected within the Stabroek Block in the vicinity of the Liza Phase 2 PDA. Pollutants sampled included PM_{10}, CO, SO_2, H_2S, NO_2, total non-methane VOCs, and selected speciated VOCs.

- From 2 May through 13 May 2018, air quality monitoring equipment was deployed on a fishing trawler and additional samples were collected within the Stabroek Block in the vicinity of the Liza Phase 2 PDA. Pollutants sampled included PM with an aerodynamic diameter of less than 2.5 micrometers ($PM_{2.5}$), CO, SO_2, H_2S, NO_2, total non-methane VOCs, and selected speciated VOCs.
- From 22 April through 26 April 2019, air quality monitoring equipment was deployed on an offshore support vessel and samples were collected within the vicinity of the Payara PDA. Pollutants sampled included PM_{10}, $PM_{2.5}$, CO, SO_2, H_2S, NO_2, total non-methane VOCs, and selected speciated VOCs.

Reports documenting the 2016, 2018, and 2019 monitoring campaigns can be found in the Liza Phase 1 EIA, Liza Phase 2 EIA, and Payara EIA, respectively (ERM 2017; ERM et al. 2018; ERM 2020).

Because the monitoring campaigns were all conducted in a relatively localized portion of the Stabroek Block, the results from all four campaigns are considered to be relevant for the purpose of characterizing ambient offshore air quality in the vicinity of the PDA. The measurements from all four campaigns found that ambient concentrations of constituents were generally below laboratory detection limits, with the exception of PM_{10} (measured concentrations ranging from non-detectable to 32 $\mu g/m^3$), $PM_{2.5}$ (measured concentrations ranging from non-detectable to 15 $\mu g/m^3$), and non-methane VOCs. During the first three offshore monitoring campaigns, the reported non-methane VOC concentrations for samples ranged from 2 to 290 parts per billion by volume (ppb(v)). For the 2019 monitoring program, reported non-methane VOC concentrations were considerably higher, ranging from 83 to 4,533 ppb(v). While the 2019 VOC measurements were significantly higher than the measurements from previous campaigns, concentrations of those speciated VOC constituents for which health guidelines have been established were all below their corresponding guideline concentrations.

For all four offshore monitoring campaigns, chemical analysis of the PM samples found that the most abundant elements in the collected particulate mass were sodium and chlorine—the most likely source of which is sea salt.

Laboratory-reported concentrations of CO, SO_2, H_2S, and NO_2 were all below laboratory reporting limits (i.e., non-detectable) for all four monitoring campaigns. The absence of detectable CO in any of the samples indicates that the monitoring campaigns were not significantly biased by emissions from the engines of the ships on which the ambient air quality monitoring instruments were deployed.

Existing Conditions—Onshore Air Quality

Given the scarcity of available information regarding onshore ambient air quality in Guyana, EEPGL commissioned an onshore ambient air-quality monitoring program in August 2018. To date, monitoring has been conducted at three onshore sites (see Figure 6.1-1). The air quality monitoring report documenting the onshore ambient air quality monitoring conducted to date is included in Appendix E, Ambient Onshore Air Quality Monitoring Report.

Figure 6.1-1: Onshore Ambient Air Quality Monitoring Sites

The onshore monitoring sites and their rationale for selection are as follows:

- New Amsterdam (Rose Hall Estate), Berbice. The New Amsterdam site was selected to represent rural, near-coast conditions, upwind of the Georgetown urban area. Monitoring was performed at this site from 15 October 2018 through 3 December 2018.
- Carifesta, Georgetown. The Carifesta monitoring site was established adjacent to the Guyana Telephone & Telegraph, Carifesta Avenue location. This coastal site represents a more urban setting compared to the New Amsterdam site, but is still generally upwind of larger point source emission sources in the Georgetown urban area. This site was monitored twice—from 15 August 2018 through 3 October 2018, and from 11 December 2018 through 21 March 2019. The initial Carifesta monitoring period characterized air quality during the dry season, while the second deployment was representative of the rainy season.
- New Guyana School. This monitoring site, near the east bank of the Demerara River, is generally downwind of the most densely populated and developed areas of Georgetown. It is thus expected to be representative of the higher ambient concentrations of pollutants that could be emitted from the Georgetown urban area. This location was selected to assess existing air quality where emissions sources are most heavily concentrated (i.e., in the most heavily populated area); this allowed for conservative estimations of future air quality that incorporate impacts from the Project in the area where the highest concentrations of existing air pollutants were expected. Monitoring was performed at this site from 12 April 2019 through 25 August 2019.

The pollutants assessed at each site included PM_{10}, $PM_{2.5}$, CO, SO_2, H_2S, NO_2, and the non-methane VOC compounds benzene, toluene, ethylbenzene, and xylenes (BTEX). All seven parameters were measured continuously or semi-continuously during the referenced monitoring periods. At the New Amsterdam and Carifesta sites, local meteorological parameters were also monitored at collocated sites. At the New Guyana School site, wind speed and direction measurements were integrated with the air quality measurement system.

The onshore measurements of PM_{10}, $PM_{2.5}$, CO, SO_2, H_2S, NO_2, and BTEX at all three onshore monitoring sites are summarized in Tables 6.1-3 through 6.1-12. As illustrated in the tables, maximum 24-hour average and “full monitoring period” average PM concentrations (both PM_{10} and $PM_{2.5}$) were near or exceeded WHO guideline values at all three onshore monitoring sites.

PM_{10}, and to a lesser extent $PM_{2.5}$, is generated by physical operations. It is likely that the elevated concentrations measured at all three sites were influenced by vehicle traffic (engine emissions, rubber tire dust, resuspended road dust) and open burning. The Carifesta site may have also received sea salt inputs due to its proximity to the coast. The sources of New Amsterdam PM_{10} ambient air impacts likely included agricultural emission sources (tilling, harvesting, and residue burning). At New Guyana School, the sources of PM_{10} ambient air impacts likely included agricultural emission sources as well as vehicle emissions.

In most cases, the primary source of $PM_{2.5}$ is atmospheric chemical reaction of precursor gases that forms fine particles. Common precursor gases are SO_2 and NO_2 from fuel combustion, as

well as ammonia from livestock operations. Combustion emissions from vehicle engines and open burning are probably also $PM_{2.5}$ emission sources impacting the three monitoring sites.

With respect to PM_{10} and $PM_{2.5}$, the comparison between the full monitoring period averages and the WHO and USEPA annual average guideline values should be considered indicative, rather than directly comparable, as the monitoring durations at each of the three sites were less than 365 days (between 50 and 141 days). The nature of atmospheric dispersion is such that average values generally decrease as the averaging period increases. Additionally, the measured maximum 24-hour average PM_{10} and $PM_{2.5}$ values cannot be directly compared with the USEPA and WHO guideline values since those guidelines are intended for comparison to statistical values (i.e., not the single highest average values), which would be lower than the highest average values.

The monitoring results for CO, NO_2, H_2S, and SO_2 were all below the WHO and USEPA guideline values. The low concentrations limit the extent to which NO_2 or SO_2 would be likely to promote ozone or secondary $PM_{2.5}$ formation.

The only measured exceedance of a gaseous pollutant criterion was the 24-hour average benzene levels at the Carifesta monitoring site. At Carifesta, the maximum 24-hour average was significantly higher than the 24-hour USEPA guideline value. The maximum 24-hour average value includes a single 6-minute sample that registered well above the calibration range of the analyzer. While this anomalous measurement is considered to be an outlier, it was not invalidated since all quality control parameters were within tolerance. Even if the outlier value is excluded, the maximum 24-hour average would still have exceeded the guideline value by more than 50 percent at the Carifesta site. Motor vehicle emissions may have been responsible for the measured values since there are no obvious nearby stationary benzene emission sources upwind of the Carifesta site. The Carifesta site is situated between two roadways that are often busy and sometimes congested. The sample inlet was located 34 meters (111.5 feet) from Carifesta Road and 69 meters (226.4 feet) from Seawall Public Road—making vehicle emissions a likely source. At the New Amsterdam and the New Guyana School monitoring sites, the maximum 24-hour average benzene measurements were significantly lower than the USEPA guideline value.

Table 6.1-3: Summary of PM_{10} Monitoring Results

Site	Maximum 1-Hour Average ($\mu g/m^3$)	Maximum 24-Hour Average ($\mu g/m^3$)	Monitoring Period Average [a] ($\mu g/m^3$)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	61.9	37.3	17.3	91%	45
Carifesta #2 (rainy season)	266.8	154.3	33.3	97%	93
Carifesta (combined)	266.8	154.3	28.3	95%	138
New Amsterdam	110.7	39.8	20.6	99%	50
New Guyana School	103.3	60.0	25.5	97%	132

Site	Maximum 1-Hour Average (µg/m^3)	Maximum 24-Hour Average (µg/m^3)	Monitoring Period Average [a] (µg/m^3)	Data Recovery	Valid Monitoring Days
Guideline	—	45 (WHO) 150 (USEPA)	15 (WHO Annual)		

[a] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts.

Table 6.1-4: Summary of $PM_{2.5}$ Monitoring Results

Location	Maximum 1-Hour Average (µg/m^3)	Maximum 24-Hour Average (µg/m^3)	Monitoring Period Average [a] (µg/m^3)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	31.8	13.1	7.1	91%	45
Carifesta #2 (rain season)	92.7	53.1	12.7	97%	93
Carifesta (combined)	92.7	53.1	11.0	95%	138
New Amsterdam	38.3	13.5	6.8	99%	50
New Guyana School	45.8	18.2	9.3	97%	132
Guideline	—	15 (WHO) 35 (USEPA)	5 (WHO Annual) 12 (USEPA Annual)		

[a] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts.

Table 6.1-5: Summary of CO Monitoring Results

Location	Maximum 1-Hour Average (ppm)	Maximum 8-Hour Average (ppm)	Monitoring Period Average (ppm)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	1.36	1.01	0.43	99%	50
Carifesta #2 (rainy season)	1.45	1.15	0.51	99%	98
Carifesta (combined)	1.45	1.15	0.48	99%	148
New Amsterdam	1.05	0.66	0.35	98%	50
New Guyana School	1.20	0.86	0.49	95%	131
Guideline	30.5 (WHO) 35 (USEPA)	8.7 (WHO) 9.0 (USEPA)	—		

Table 6.1-6: Summary of NO_2 Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Monitoring Period Average [a] (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	15.0	3.1	96%	50
Carifesta #2 (rainy season)	12.5	-0.7 [b]	95%	98
Carifesta (combined)	15.0	0.6	95%	148
New Amsterdam	21.7	-1.4 [b]	79%	40
New Guyana School	15.8	1.3	93%	130
Guideline	106.4 (WHO) 100 (USEPA)	5.3 (WHO Annual) 53 (USEPA Annual)		

[a] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts.
[b] Negative values result when ambient concentrations are very low and normal instrument drift results in a negative value. This is consistent with accepted reporting convention. If drift is excessive—usually due to instrument malfunction—negative values are invalidated.

Table 6.1-7: Summary of SO_2 Monitoring Results

Location	Maximum Daily 1-hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	7.2	0.3	-1.0 [a]	96%	50
Carifesta #2 (rainy season)	2.9	0.3	-0.1 [a]	95%	98
Carifesta (combined)	7.2	0.3	-0.4 [a]	95%	148
New Amsterdam	-0.1 [a]	-1.0 [a]	-1.3 [a]	95%	50
New Guyana School	11.7	3.3	0.9	93%	132
Guideline	75 (USEPA)	15 (WHO)	—		

[a] Negative values result when ambient concentrations are very low and normal instrument drift results in a negative value. This is consistent with accepted reporting convention. If drift is excessive—usually due to instrument malfunction—negative values are invalidated.

Table 6.1-8: Summary of H_2S Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	9.5	1.9	0.4	96%	50
Carifesta #2 (rainy season)	20.0	1.3	0.1	95%	98
Carifesta (combined)	20.0	1.9	0.2	95%	148

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
New Amsterdam	5.7	0.4	-0.1 [a]	95%	50
New Guyana School	75.9	16.0	2.8	93%	132
Guideline	—	107.6 (WHO 24-hour)	—		

[a] Negative values result when ambient concentrations are very low and normal instrument drift results in a negative value. This is consistent with accepted reporting convention. If drift is excessive—usually due to instrument malfunction—negative values are invalidated.

Table 6.1-9: Summary of Benzene Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	1,272.6	131.9	18.4	95%	47
Carifesta #2 (rainy season)	NA	NA	NA	NA	NA
Carifesta (combined)	NA	NA	NA	NA	NA
New Amsterdam	7.9	0.4	0.0	99%	50
New Guyana School [a]	NA	0.7	NA	NA	8
New Guyana School [b]	16.1	0.8	0.0	74%	21
Guideline	—	9.4 (USEPA)	—		

NA = not applicable
[a] Data from integrated 24-hour Summa samples
[b] Data from Mocon installed on 27 June and operated until 22 August 2019

Table 6.1-10: Summary of Toluene Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Maximum Weekly Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	1,134.6	169.5	20.7	94%	47
Carifesta #2 (rainy season)	NA	NA	NA	NA	NA
Carifesta (combined)	NA	NA	NA	NA	NA
New Amsterdam	6.7	5.4	5.0	99%	50
New Guyana School [a]	NA	6.0	NA	100%	8
New Guyana School [b]	2,396.7	99.9	0.0	74%	21
Guideline	—	—	69 (WHO)		

NA = not applicable
[a] Data from integrated 24-hour Summa samples
[b] Data from Mocon installed on 27 June and operated until 22 August 2019

Table 6.1-11: Summary of Ethylbenzene Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	31.6	3.3	0.08	94%	47
Carifesta #2 (rainy season)	NA	NA	NA	NA	NA
Carifesta (combined)	NA	NA	NA	NA	NA
New Amsterdam	0.6	0.1	0.0	99%	50
New Guyana School [a]	NA	0.2	ND	100%	8
New Guyana School [b]	18.4	0.0	0.0	74%	21
Guideline	—	—	0.23 [c] (USEPA Annual)		

NA = not applicable; ND = below minimum laboratory reporting level of 0.14 ppb(v)
[a] Data from integrated 24-hour Summa samples
[b] Data from Mocon installed on 27 June and operated until 22 August 2019
[c] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts.

Table 6.1-12: Summary of Xylenes Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	137.1	12.3	0.4	94%	47
Carifesta #2 (rainy season)	NA	NA	NA	NA	NA
Carifesta (combined)	NA	NA	NA	NA	NA
New Amsterdam	14.4	0.9	0.1	99%	50
New Guyana School [a]	NA	0.6	NA	100%	8
New Guyana School [b]	0.0	0.0	0.0	74%	21
Guideline	—	100 (USEPA)	—		

NA = not applicable
[a] Data from integrated 24-hour Summa samples
[b] Data from Mocon installed on 27 June and operated until 22 August 2019

6.1.2.2. Existing Conditions—Climate

Guyana has a wet tropical climate characterized by two pronounced wet seasons and year-round warm temperatures. The bimodal wet/dry regime is caused by the annual migration of the Inter-Tropical Convergence Zone (ITCZ), which changes latitude based on the Earth's position and angle in relation to the sun. Northward movement of the ITCZ occurs as energy from the sun is strongest in the Northern Hemisphere during the Northern Hemisphere's summer, thereby increasing solar heating in that hemisphere. The relative change in solar heating slightly shifts the atmosphere's primary circulation cells, which causes the area of trade wind

convergence closest to the Equator to migrate seasonally. In the areas closest to the ITCZ, one can typically expect increased thunderstorm activity and heavy rainfall between mid-April and the end of July, with peak rainfall in June. This period is known in Guyana as the primary wet season. The secondary wet season occurs during the southward migration of the ITCZ from mid-November to the end of January, with typical peak rainfall in December. The intervening periods (January to April and mid-August to mid-November) are typically relatively dry, but rain can occur at any time of the year. Average monthly rainfall totals range between approximately 100 millimeters and 300 millimeters (4 inches to 12 inches) (World Weather & Climate Information 2016).

The climate in Guyana is influenced by the El Niño Southern Oscillation. During El Niño years (approximately every 3 to 6 years), Guyana's long dry season is often drier and warmer than normal; during La Niña years, wetter- and cooler-than-normal conditions typically prevail during the long wet season as compared to other years (McSweeney et al. 2010). With respect to the ambient air quality presented herein, El Niño conditions existed in late 2018 and into mid-2019.

Although the ITCZ moves seasonally, it is generally located between 5 degrees (°) North latitude and 5° South latitude. North and south of the ITCZ, atmospheric circulation and the Coriolis impact create global wind patterns including the Northern Hemisphere's trade winds and westerlies (NOAA 2008). Guyana's coastal zone is located approximately between 6° and 8° north latitude, and the Stabroek Block is located between 7° and 8° latitude, both within the southern portion of the area impacted by the trade winds. The influence of the trade winds produces a strongly dominant east-northeast wind offshore of Guyana, which gives rise to the afternoon "sea breeze" that usually blows inland across coastal Guyana from the ocean.

Annual average temperatures in coastal Guyana are relatively constant, with an annual average daytime maximum temperature of 29.6 degrees Celsius (°C) (85.3 degrees Fahrenheit [°F]) and an annual average nighttime minimum temperature of 24.0 °C (75.2 °F). The average daily temperature is approximately 27 °C (81 °F). Relative humidity is high at 80 percent or more year-round in the coastal zone.

To develop more specific climate information regarding offshore conditions in the vicinity of the PDA, EEPGL commissioned deployment of a surface met buoy in the Stabroek Block to collect information on existing meteorological conditions. With respect to atmospheric conditions, the instrument measured and logged the following:

- Air temperature
- Water temperature
- Atmospheric pressure
- Relative humidity
- Solar radiation
- Precipitation
- Wind speed
- Wind direction
- Gust speed

The above information for the five deployments of the surface met buoy between March 2016 and April 2018 is included as Appendix F, Onshore and Offshore Meteorological Data.

To develop more specific climate information regarding onshore climate conditions, EEPGL commissioned deployment of a meteorological station at two of the three ambient onshore monitoring air quality sites discussed above (Carifesta and New Amsterdam). The instrument measured and logged the following:

- Air temperature
- Relative humidity
- Atmospheric pressure
- Solar radiation
- Precipitation
- Wind speed
- Wind direction
- Gust speed

The above information for the meteorological station deployments between December 2017 and April 2019 is included as Appendix F, Onshore and Offshore Meteorological Data.

6.1.2.3. Current Scientific Understanding of Consequences of Climate Change

As part of placing existing climate conditions in context, a review of the current scientific understanding of the potential consequences of global climate change was conducted. The review focused on the following climatic conditions:

- Sea level rise
- Ocean temperature and ocean acidification
- Storm intensity

The following discussion references the *Summary for Policymakers* (SPM) from the Intergovernmental Panel on Climate Change (IPCC) Working Group 1 (WG1) report, *AR6 Climate Change 2021: The Physical Science Basis* (IPCC 2021). This report presents global and regional findings, and it is important to note that statements made in the SPM regarding regional-scale climate change may not apply specifically to Guyana. The report does assess some region-specific climate changes in specific, defined regions (see Figure SPM.3) in Chapter 12. However, with the exception of heavy precipitation and relative sea level, the climatic conditions considered here are not specifically assessed for the region that includes Guyana (northern South America or “NSA”). Notably, there is low confidence in current extreme precipitation trends in NSA due to lack of observations; climate projections indicate a medium confidence in future increases in intensity and frequency of heavy precipitation in the NSA region. Projected changes in relative sea level for South America under both low and high emission scenarios are similar to projected global mean sea level rise under the same scenarios.

Sea Level Rise

The IPCC (2021) reports that global mean sea level increased by 200 millimeters (7.9 inches) between 1901 and 2018, with the average rate of sea level rise at 1.3 millimeters (0.05 inch) per year between 1901 and 1971, increasing to 1.9 millimeters (0.07 inch) per year between 1971 and 2006, and further increasing to 3.7 millimeters (0.15 inch) per year between 2006 and 2018 (high confidence).[1]

The IPCC concludes that it is virtually certain that global mean sea level will continue to rise over the 21st century. Relative to 1995–2014, the IPCC predicts the likely global mean sea level rise by 2100 is 0.28 to 0.55 meter (11.0 to 21.7 inches) under the very low GHG emissions scenario2, 0.32 to 0.62 meter (12.6 to 24.4 inches) under the low GHG emissions scenario, 0.44 to 0.76 meter (17.3 to 29.9 inches) under the intermediate GHG emissions scenario, and 0.63 to 1.01 meters (24.8 to 39.8 inches) under the very high GHG emissions scenario, and by 2150 is 0.37 to 0.86 meter (14.6 to 33.9 inches) under the very low scenario, 0.46- 0.99 meter (18.1 to 39.0 inches) under the low scenario, 0.66 to 1.33 meters (26.0 to 42.5 inches) under the intermediate scenario, and 0.98 to 1.88 meters (38.6 to 74.0 inches) under the very high scenario. Global mean sea level rise above the likely range—approaching 2 meters (79 inches) by 2100 and 5 meters (197 inches) by 2150 under a very high GHG emissions scenario (low confidence)—cannot be ruled out due to deep uncertainty in ice sheet processes. From a regional perspective, the IPCC reports that relative sea-level rise is extremely likely to continue in the oceans around Central and South America, contributing to increased coastal flooding in low-lying areas (high confidence) and shoreline retreat along most sandy coasts (high confidence) (IPCC 2021).

In addition to the IPCC 2021 report, information related to regional sea level rise was researched. Based on data from 1993 to 2010 (WHO et al. 2020), regional sea-level trends in the Caribbean correspond to an average rise of 1.7 (±1.3) millimeters (0.066 [±0.051] inch) per year. Other data for the Atlantic coast of South America show average rise values of 3.6 millimeters (0.14 inch) per year, based on data from 1993 to 2020 (WMO 2021).

The World Bank estimates that Guyana is one of the most vulnerable countries to global climate change due to its low-lying coastal areas, many of which are below mean sea level, and a high percentage of the population and critical infrastructure located along the coast (World Bank 2016). As such, the country invests continuously in the construction and maintenance of

[1] The IPCC 2021 report discusses its predictions using levels of confidence expressed using five qualifiers: *very low*, *low*, *medium*, *high*, and *very high*; and assessed likelihoods of an outcome or a result as follows: *virtually certain* 99 to 100 percent probability, *very likely* 90 to 100 percent probability, *likely* 66 to 100 percent probability, *about as likely as not* 33 to 66 percent probability, *unlikely* 0 to 33 percent probability, *very unlikely* 0 to 10 percent probability, *exceptionally unlikely* 0 to 1 percent probability. Where these terms are used in Section 6.1.2.3, they refer to this nomenclature.

[2] The IPCC 2021 report discusses predicted future conditions under five key scenarios, as follows: Scenario SSP1-1.9 (referred to as the *very low GHG emissions* scenario), Scenario SSP1-2.6 (referred to as the *low GHG emissions* scenario), Scenario SSP2-4.5 (referred to as the *intermediate GHG emissions* scenario), Scenario SSP3-7.0 (referred to as the *high GHG emissions* scenario), and Scenario SSP5-8.5 (referred as the *very high GHG emissions* scenario).

sea and river defense infrastructure. In addition, significant efforts are being made to protect and enhance natural sea defense mechanisms, in particular mangrove ecosystems.

Ocean Temperature and Ocean Acidification

The IPCC concludes that it is virtually certain that the global upper ocean (0 to 700 meters [0 to 2,300 feet]) has warmed since the 1970s, and that GHG emissions since 1750 have committed the global ocean to future warming (high confidence). Over the rest of the 21st century, the IPCC predicts likely ocean warming ranges from 2 to 4 times (low GHG emissions scenario) to 4 to 8 times (very high GHG emissions scenario) the 1971–2018 change. The IPCC concludes it is virtually certain that ocean pH has declined globally over the last 40 years. Ocean acidification and associated reductions in the saturation state of calcium carbonate—a constituent of skeletons or shells of a variety of marine organisms—is expected to increase in the 21st century under all emissions scenarios (high confidence). Based on multiple lines of evidence, the IPCC predicts upper ocean stratification (virtually certain), ocean acidification (virtually certain), and ocean deoxygenation (high confidence) will continue to increase in the 21st century, at rates dependent on future emissions. Ocean acidification and deoxygenation have already emerged over most of the global open ocean. Over the past 2 to 3 decades, a pH decline in the ocean interior has been observed in all ocean basins (high confidence) (IPCC 2021).

Storm Intensity

The IPCC reports that frequency and intensity of heavy precipitation events have increased since the 1950s over most land area for which observational data are sufficient for trend analysis (high confidence); Guyana does not fall within any of the regions for which there are enough data to evaluate these trends, so it is unclear from the IPCC report whether this is true specifically for Guyana. The IPCC concludes that it is very likely that heavy precipitation events will intensify and become more frequent in most regions with additional global warming. At the global scale, extreme daily precipitation events are projected to intensify by about 7 percent for each 1°C (1.8°F) of global warming. The proportion of intense tropical cyclones (Categories 4-5) and peak wind speeds of the most intense tropical cyclones are projected to increase at the global scale with increasing global warming (IPCC 2021).

The IPCC concludes that it is likely that the global proportion of major (Category 3–5) tropical cyclone occurrence has increased over the last four decades and that these changes cannot be explained by internal variability alone (medium confidence). However, the IPCC states that there is low confidence in long-term (multi-decadal to centennial) trends in the frequency of “all-category” tropical cyclones, and that while data support a high confidence that climate change increases heavy precipitation associated with tropical cyclones, data limitations inhibit clear detection of past trends on the global scale (IPCC 2021).

In addition to the IPCC 2021 report, information related to regional storm intensity was researched. In 2020, the Atlantic Basin, which includes Guyana, registered a historical record of 30 storms, two of which reached a Category 4—where wind speeds exceed 209 kilometers (130 miles) per hour (WHO and UNFCCC 2020; National Hurricane Center and Central Pacific

Hurricane Center Undated). Caribbean regional climate projections estimate that Category 4 and 5 hurricane frequency is expected to increase by 25 to 30 percent in the future (USAID 2018). Intensity of tropical cyclones is expected to increase on average by 1 to 10 percent according to model projections for a 2°C (3.6°F) warming of the globe (GFDL 2021).

6.1.3. Impact Assessment—Air Quality, Climate, and Climate Change

This section addresses potential impacts on air quality due to criteria pollutant emissions resulting from planned Project activities. This section also addresses GHG emissions resulting from planned Project activities. As discussed in more detail in Section 6.1.3.4, Characterization of Potential Impacts—Climate / Climate Change, predicting the impact of local GHG emissions on local climate or global climate change is not feasible due to the multiple factors—beyond that of a single project—that drive global climate change predictions. Potential climate impacts and climate change are a global concern from cumulative worldwide GHG emissions, and these cannot be assessed on a project-specific basis using the typical assessment methodology.

The key potential impacts assessed herein include increases in ambient concentrations of criteria pollutants as a result of stationary and mobile combustion sources associated with planned Project activities, and GHG emissions from these same sources.

6.1.3.1. Relevant Project Activities and Potential Impacts

Emissions generated by the Project emanate from two source categories:

- Specific point sources such as the power-generating units and diesel engines on drill ships and on the Floating Production, Storage, and Offloading (FPSO) vessel, flares used non-routinely to combust associated gas when not consumed as fuel gas on the FPSO or re-injected back into the reservoir; and
- General area sources such as support vessels, construction vessels, tug boats, and helicopters.

Such emissions contribute to increases in the ambient air concentrations of criteria pollutants and will also increase Guyana's national GHG emissions inventory.

Regarding potential air quality impacts from criteria pollutants, depending on the magnitude and extent of the increases in ambient air criteria pollutant concentrations relative to the location of potential human receptors onshore in Guyana, the increases from Project activities would have the potential to contribute to health impacts. Because potential air quality-related health impacts for Project workers will be addressed through standard occupational exposure guidelines, the air quality impact assessment was limited to consideration of potential onshore community receptors. ExxonMobil and its affiliates generally follow the American Conference of Governmental Industrial Hygienist's Threshold Limit Values to set the exposure limits for chemical, physical, and biological substances.

Table 6.1-13 summarizes the Project stages and activities that could result in potential Project impacts on air quality and climate / climate change.

Table 6.1-13: Summary of Relevant Project Activities and Key Potential Impacts—Air Quality and Climate / Climate Change

Stage	Project Activity	Resource	Key Potential Impacts
Development Well Drilling FPSO and SURF Installation, Commissioning, and Start-up Decommissioning	Operation of drill ships (power generation and engines), marine support and installation vessels, and support aircraft	Air quality (onshore population as receptors)	Increased concentrations of pollutants in ambient air, potentially contributing to health impacts for onshore receptors
		Climate / Climate Change	Emissions of GHGs from the Project, contributing to global GHG emissions
Production Operations	Operation of FPSO (power generation and engines), marine support vessels, and support aircraft; temporary, non-routine flaring of associated gas when not re-injected	Air quality (onshore population as receptors)	Increased concentrations of pollutants in ambient air, potentially contributing to health impacts for onshore receptors
		Climate / Climate Change	Emissions of GHGs from the Project, contributing to global GHG emissions

SURF = Subsea, Umbilicals, Risers, and Flowlines

6.1.3.2. Emissions of Air Quality Pollutants

Emissions of air quality pollutants from the Project have been estimated based on a number of factors, including activity levels, fuel types, equipment capacities, and standard emission factors that are published by the USEPA in the publication *AP-42: Compilation of Air Pollutant Emission Factors* (USEPA Undated). As described in AP-42, an emission factor is a representative value that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., milligrams of nitrogen oxides emitted per cubic meter of natural gas combusted). In most cases, these factors are averages of available data of an acceptable quality and are generally assumed to be representative of long-term averages for a particular type of source (USEPA Undated).

Embedded Controls

The Project has been inherently designed to incorporate a number of embedded controls that will serve to reduce air pollutant emissions, as well as GHG emissions (discussed further below) from Project sources. Table 6.1-14 includes a summary of these embedded controls. Additionally, EEPGL has indicated its willingness to engage with the EPA and other government agencies as necessary with a view to progressing appropriate environmental initiatives such as air quality monitoring in keeping with its commitment to minimizing environmental impacts.

Table 6.1-14: Embedded Controls Contributing to Reductions in Atmospheric Emissions

Embedded Controls
Provide installed spares on compressors for the Flash Gas Compression, Main Gas Compression, and Re-Injection Gas Compression systems, such that when one compressor trips, the spare (backup) unit can be started, reducing non-routine flaring frequency and volume/duration.
If well testing[3] is performed, implement the following measures: • Flow only the minimum volume of hydrocarbons required for the test and reduce the test duration to the extent practical; • Use an efficient test-flare burner head equipped with an appropriate combustion enhancement system to minimize incomplete combustion, black smoke, and hydrocarbon fallout4 to the sea; • Provide adequate gas sensors that are appropriately located during testing operations, to ensure all sources of gas can be detected; • Monitor pipes and joints on a daily basis for leakages and fugitive emissions. Burn all collected gaseous streams in high-efficiency flares, and implement and maintain a leak detection and repair program; • Keep the well test to the minimum practical time, in keeping with a pre-approved schedule with the EPA. Notify the EPA immediately in case of any deviation/variation to the well test; and • Provide sufficient compressed air to the oil burner for efficient flaring assignment.
Use aero-derivative turbines instead of industrial turbines on the FPSO.
Install waste heat recovery units (WHRUs) on turbine generators to reduce the demand of more power generation or fired heaters, thus decreasing fuel gas consumption.
Use a crude–crude exchanger to recover heat from the dead crude to heat up live crude, instead of using a fired heater.
Use a gas turbine to drive the export/injection compressors directly, allowing savings in fuel versus using a gas turbine to generate electricity, and then using an electric motor to drive the compressor—reducing motor losses and power generation losses.
Use large, high-voltage motors, which are more efficient than industry-standard machines.
Implement an FPSO topsides leak detection and repair program to reduce fugitive emissions.
Implement a flare minimization plan for the Project.
Instead of continuous flaring of gas produced during crude oil production, re-inject associated gas that is not used as fuel gas on the FPSO—excluding *de minimis* sources not captured by the VRU—into the reservoir, to avoid routine flaring of associated gas.
Use highly efficient combustion equipment that utilizes recovery heat systems as part of the heat and power production.
With respect to non-routine flaring of associated gas, the following measures will be implemented: • Properly inspect, maintain, monitor, certify, and function-test flare equipment prior to and throughout operations; • Design and build combustion equipment to appropriate engineering codes and standards; • Use flare tip of a non-pollutant type, with low NOx emissions, and a burning efficiency high enough to support low hydrocarbon emissions to the atmosphere; • Minimize risk of pilot blowout by ensuring sufficient exit velocity and provision of wind guards; • Use a reliable pilot ignition system; • Install high-reliability instrument pressure protection systems, as appropriate, to reduce overpressure events and avoid or reduce flaring situations; • Minimize liquid carryover and entrainment in the gas flare stream with a suitable liquid separation system, with sufficient holding capacity for liquids that may accumulate, and which is designed in accordance with good engineering practice;

[3] While well testing is not planned for the Project, there is the potential it could be needed, in which case EEPGL will implement the listed measures.
[4] Hydrocarbons that are deposited on the ocean surface due to both wet and dry deposition processes.

• Equip liquid separation system (e.g., knockout drum) with high-level facility shutdown or high-level alarms and empty as needed to increase flare combustion efficiency; • Implement source gas reduction measures (i.e., gas re-injection into reservoir) to the extent possible to avoid or reduce flaring from FPSO; • Minimize flaring from purges and pilots without compromising safety through measures such as installation of purge gas reduction devices, vapor recovery units, inert purge gas, and soft seat-valve technology where appropriate, and installation of pilot flares; and • Minimize flame lift off and/or flame lick.
Employ reasonable efforts and execute a maintenance program to minimize equipment breakdowns and plant upsets that could result in flaring, and make provisions for equipment sparing and plant turn-down protocols where practical.
Implement inspection, maintenance, and surveillance programs to identify and prevent unplanned emissions to atmosphere onboard the FPSO.
Avoid routine venting (excludes tank flashing emissions, standing/ working/breathing losses, secondary seals) except during safety and emergency conditions.
Adopt measures as far as practicable, in accordance with the Global Gas Flaring and Venting Reduction Partnership when considering venting and flaring options under emergency or upset conditions.
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, and at their optimal levels to minimize atmospheric emissions to the extent reasonably practicable.
Shut down (or throttle down) sources of combustion equipment in intermittent use where reasonably practicable in order to reduce air emissions.

As noted in Table 6.1-14, several of the embedded controls relate to minimization of flaring from the Project's FPSO production operations. To support this embedded control, EEPGL will develop a flaring minimization plan to document the design measures and operational practices that minimize flaring during Project FPSO operations. The following sub-section provides an overview of flaring minimization.

Guiding Principles

It is EEPGL's policy to conduct its business in a manner that is compatible with the balanced environmental and economic needs of the communities in which it operates. EEPGL is committed to continuous efforts to improve environmental performance throughout its operations.

The capability to conduct non-routine flaring is an integral part of safe operations for any production facility. The flare provides a consistent, dependable utility for safely managing hydrocarbons when needed to avoid overpressure events on process vessels. Combining technologies, procedures, and work practices with comprehensive flare management can result in significant reductions in non-routine flaring during operations.

Operating in a safe and environmentally sound manner is an essential part of the EEPGL philosophy and efforts will be made to minimize flaring emissions during maintenance, commissioning/start-up, and shutdown operations to the extent practical.

Flare Minimization Design and Practices

The FPSO will be designed, constructed, and operated to avoid routine flaring of associated gas. For events where flaring is the only viable solution, such as maintenance, process upsets,

commissioning/start-up, and emergency shutdowns, the below measures, practices, and technologies are used to minimize flaring emissions.

Flaring emissions are reduced first through facility design. The FPSO is designed to recover associated gas to be used as fuel on the FPSO and re-inject the remaining associated gas—excluding *de minimis* sources not captured by the Vapor Recovery Unit (VRU)—back into the reservoir, except during times of process upsets such as injection system unavailability - which may require temporary, non-routine flaring. Through designing the Project to use associated gas as fuel on the FPSO and re-injecting the remaining volumes as described above, flaring emissions have been minimized. Further, the Project has applied additional compressor sparing and vapor recovery to reduce the frequency and/or duration of flaring.

In addition, the flare systems onboard the FPSO are designed and built to appropriate engineering codes, which promotes efficient and reliable combustion of gas, when necessary.

Maintenance Programs

Proactive and preventative maintenance and testing programs will reduce flaring by minimizing downtime from equipment failure and will promote continuous maximum flare efficiency. The key aspects of these programs include preventative maintenance, corrective maintenance, and capacity enhancements, which can increase reliability and reduce unplanned equipment downtime. A robust facility preventative maintenance program can reduce the number of process upset events. The FPSO will use a computerized maintenance management system to schedule efficient use of maintenance time so that the proper equipment inventory is maintained. In addition, a facility integrity management system will be in place; this is a primary driver for inspections of vessels, piping, and equipment that cannot be completed while the facility is online.

Procedures

Additional measures will be put in place to minimize flaring through procedural activities. Operations will follow specifically developed procedures for starting up and shutting down equipment. By following these procedures, flaring emissions will be minimized.

Prior to any major maintenance event, a specific plan will be developed in advance that includes a review of potential flaring and evaluation of possible mitigations to minimize any flaring.

Flare minimization steps may include the following measures to avoid or reduce flaring:

- When feasible, perform maintenance on one area without impacting other operations on the facility. This will allow other operations to continue normally without the need to flare excess gas.
- During planned shutdowns, start up installed spare equipment, curtail hydrocarbon production, or throttle-back equipment.
- Plan maintenance activities during optimal periods. Scheduling maintenance during periods of minimum capacity needs and/or following planned process unit shutdowns has the potential of minimizing flaring activities.

- Optimize planned shutdowns of the FPSO for major maintenance, known as a turnaround. The following procedures would be used to minimize flaring during FPSO turnarounds:
  - Prior to turnaround, identify critical equipment to be serviced to avoid downtime and associated flaring.
  - Phase equipment and process unit shutdowns to minimize fuel gas imbalances that may result in additional flaring.
  - Phase equipment and process unit start-ups to minimize start-up duration and the flaring associated with these transitional operations.

Monitoring

Monitoring of the facility will be provided to manage operational events that may cause flaring.

Operators will conduct routine rounds on the FPSOs to visually inspect equipment, including the flare system. It is important that equipment be visually inspected and monitored to ensure that remote instrumentation is operating correctly and to confirm that no abnormalities are present.

Additionally, the FPSO will maintain and operate instrumentation to continuously monitor and record process and flare parameters. Monitoring and control of the FPSO production operations will be performed by an Integrated Control and Safety System. The system will include primary process control, monitoring, and data acquisition, shutdown functions, operator graphics/ consoles, and visual alarm notifications. This system will allow operators to monitor what is happening in the process and help identify situations that could result in flaring events. Deviations from set parameters will cause an alarm, driving operators to intervene to prevent or mitigate an event. The alarm will be followed by an automatic trip if the deviation reaches a certain threshold.

Reporting

The following core reporting components support flare minimization and help drive improvement initiatives by tracking overall flare performance:

- The volumes of gas flared will be recorded on a daily basis.
- Flaring events resulting from upset events or unplanned maintenance that sustains a volume and/or duration above thresholds imposed by the Project permit conditions will be reported to the EPA per the Permit.
- Flaring volumes will be reported to the EPA on an annual basis.

Project-Specific Implementation

During commissioning and start-up planning, EEPGL will work to minimize the duration of start-up flaring. EEPGL will incorporate lessons learned from Liza Phase 1, Liza Phase 2, and Payara start-ups in the Yellowtail commissioning and start-up planning. In advance of start-up, EEPGL will conduct a workshop with the EPA and other appropriate regulators and seek to

align on the timeline to achieve pilot flare. Additionally, EEPGL will work with the EPA to align on operations and maintenance flaring management and mitigation measures.

Mitigation Measures

In addition to the embedded controls discussed above, the Project design has incorporated a number of additional mitigation measures that are anticipated to further reduce air pollutant emissions from Project sources. Table 6.1-15 includes a summary of these additional mitigation measures.

Table 6.1-15: Additional Mitigation Measures Contributing to Reduced Atmospheric Emissions

Mitigation Measures
Install VOC recovery on the FPSO cargo tanks, which results in a reduction in FPSO cargo tank emissions.
Install vapor recovery for low-flow process streams from produced water and triethylene glycol regeneration, resulting in a reduction in emissions to the atmosphere.
Optimize gas turbine maintenance to ensure that gas turbines are not overhauled more often than needed, and also to ensure overhauls are completed at the right time, in alignment with other FPSO maintenance activities to reduce the need to flare.
Implement trip-reduction initiatives for the gas turbines to improve reliability/availability and thus reduce flaring.

Project Emissions Inventory

To support modeling of Project emissions of air pollutants (discussed further below), the Project emissions inventory that was used as input for modeling considered all of the embedded controls and mitigation measures described above. Table 6.1-16 provides a summary of expected annual emissions from various planned Project activities for three time periods: 2023 to 2024 (development well drilling; Subsea, Umbilicals, Risers, and Flowlines [SURF] installation and commissioning; FPSO installation; and operation of related support vessels); 2025 to 2027 (continued development well drilling; operation of related support vessels; FPSO start-up and associated temporary, non-routine flaring; beginning of production operations; and tanker loading); and 2028 to 2044 (production operations following start-up, including temporary, non-routine flaring; potential continued development well drilling for the first few years of the period; operation of related support vessels; and tanker loading). For each of the time periods, the annual emissions presented for each pollutant in Table 6.1-16 subjected to modeling represents the maximum anticipated annual emissions for each source during the time period (these source-specific maximum values are not necessarily all from the same year in the time period). While there are some differences in pollutant emissions for different years within the time periods, they are relatively minor and the use of maximum emissions for the impact assessment provides a degree of conservatism in the results. In the case of non-methane VOCs (not modeled), the source-specific emissions are all from the same year (i.e., 2024, 2026, and 2029).

The Project emissions estimates account for an assumed quantity of emissions from low-level continuous flaring of pilot gas, purge gas, and other *de minimis* streams described in Chapter 2, Description of the Project, as well as temporary, non-routine flaring associated in part with upsets and maintenance, and other non-routine and/or unplanned events during the Project life cycle. Estimated emissions from non-routine flaring are included together with estimated emissions from planned activities. These estimated emissions account for a reduced duration of flaring during these non-routine events as a result of the additional compression sparing that has been included in the Project design. With respect to start-up, the Project is targeting 60 cumulative days for start-up flaring, recognizing that this would represent industry-leading performance. For the purpose of modeling, the estimated emissions are based on the conservative assumption that start-up flaring for the Project will be temporary and may require flaring for 90 cumulative days at the rate of 120 million standard cubic feet per day. In the United States offshore, flaring may occur for up to 1 year with regulatory approval (30 Code of Federal Regulations §250.1161): "[An operator] must request and receive approval from the Regional Supervisor to flare or vent gas for an extended period of time. The Regional Supervisor will specify the approved period of time, which will not exceed 1 year."

Emissions estimates are provided for two cases designated as the "Design Case" and "Modeled Case." The Design Case emissions are based on estimated annual flaring, including an estimate of non-routine flaring in accordance with design basis assumptions for the Project. The Modeled Case emissions include an additional contingency for non-routine flaring volumes and are considered to reflect a credible worst case for non-routine flaring. Operational reliability performance is best described as a range of experience. Recognizing that range, a "low side" and "high side" estimation has been included to demonstrate the potential range for experience. For the purposes of modeling, only the High Case emissions estimates are assessed—reflecting the credible worst-case resulting ambient onshore concentrations of pollutants.

Table 6.1-16: Annual Air Pollutant Emissions Summary—Yellowtail Project

Pollutant	Source Category	Design Case			Modeled Case		
		Maximum Annual Emissions (tonnes) [a,c]			Maximum Annual Emissions (tonnes) [a,c]		
		2023–2024	2025–2027	2028–2044 [f]	2023–2024	2025–2027	2028–2044 [f]
Nitrogen Oxides	FPSO	0	2,065	2,460	0	2,065	2,460
	FPSO Flaring (temporary, non-routine)	0	505	190	0	520	350
	Tanker Loading	0	240	240	0	240	240
	Area Sources [d]	2,135	1,785	880	2,135	1,785	880
	Drill Ships	1,835	945	1,415	1,835	945	1,415
	Total	3,970	5,540	5,185	3,970	5,555	5,345
Sulfur Dioxide	FPSO	0	110	125	0	110	125
	FPSO Flaring (temporary, non-routine)	0	90	35	0	90	60
	Tanker Loading	0	10	10	0	10	10
	Area Sources [d]	50	65	35	50	65	35
	Drill Ships	65	35	50	65	35	50
	Total	115	310	255	115	310	280
Particulate Matter (PM) [b]	FPSO	0	40	40	0	40	40
	FPSO Flaring (temporary, non-routine)	0	100	40	0	105	70
	Tanker Loading	0	20	20	0	20	20
	Area Sources [d]	100	130	65	100	130	65
	Drill Ships	130	70	100	130	70	100
	Total	230	360	265	230	365	295
Carbon Monoxide	FPSO	0	415	515	0	415	515
	FPSO Flaring (temporary, non-routine)	0	2,300	860	0	2,360	1,585

Pollutant	Source Category	Design Case			Modeled Case		
		Maximum Annual Emissions (tonnes) [a,c]			Maximum Annual Emissions (tonnes) [a,c]		
		2023–2024	2025–2027	2028–2044 [f]	2023–2024	2025–2027	2028–2044 [f]
	Tanker Loading	0	65	65	0	65	65
	Area Sources [d]	565	470	230	565	470	230
	Drill Ships	490	255	380	490	255	380
	Total	1,055	3,505	2,050	1,055	3,565	2,775
Hydrogen Sulfide	FPSO Flaring (temporary, non-routine)	NA (no emissions)	<5	<1	NA (no emissions)	<5	<1
Non-methane Volatile Organic Compounds (VOCs) [e]	All Sources	30	3,500	2,370	30	3,555	2,955

NA = not applicable

Notes:

[a] The annual estimated totals generally reflect the current preliminary Project schedule and production profile and remain subject to adjustment. This air pollutant emissions summary was developed based on the current design of the Yellowtail Project and reflects the best available estimates of the components and activities of the Project that will generate air pollutant emissions. Actual pollutant emissions could differ from these estimates (either upward or downward) as a function of changes, such as shorter or longer drilling duration, more or less oil and associated gas production, more or less upset or maintenance scenarios, more or less support vessel or helicopter trips, among others. Where appropriate, a degree of conservatism is reflected in the estimates. Source category-specific sub-totals are rounded up to the next 5 tonnes and the totals reflect the sum of the rounded sub-totals.

[b] PM emissions represent total PM; for the purpose of the impact assessment, the results from modeling of total PM values were used for comparison to both PM_{10} standards and $PM_{2.5}$ standards (a conservative assumption).

[c] The emission rates in this table reflect annual totals. In some cases, the activities generating the emissions are not continuous during the year, or do not operate at full capacity throughout the year. For these sources, the annual emissions reflect this non-continuous operation over the year. However, for the purpose of modeling conducted to compare with short-term (up to 24-hour) guidelines, activities were assumed to be operating at full capacity for the simulated period to reflect maximum possible short-term emission rates.

[d] Area Sources are mobile equipment such as aviation and marine support vessels (besides the FPSO and drill ships) used during drilling; installation, commissioning, and start-up; production operations; and decommissioning.

[e] Total non-methane VOC emissions are shown in this table but were not modeled, as there are no ambient air quality criteria for total non-methane VOC emissions.

[f] Development well drilling could occur for up to 5 years into the period.

6.1.3.3. Characterization of Potential Impacts—Air Quality

This section presents the assessment of potential Project impacts on air quality based on the Project emissions inventory presented above.

Air Dispersion Modeling

Air dispersion modeling was carried out to assess air quality impacts for potential onshore human receptors. The key elements of the modeling are discussed below, including receptors, source inputs, model selection, and meteorological data.

Receptors: A grid of potential receptor points was established for onshore areas in the Project AOI, with a denser grid used in coastal areas (closer to Project sources) and a coarser grid used in inland regions. For each pollutant, dispersion modeling was used to predict the maximum concentration at any time (for the relevant averaging periods) at any one of the onshore grid points; these maximum predicted concentrations were then compared to ambient air quality guidelines. Under this conservative approach, if the maximum predicted concentrations are determined to be less than the respective ambient air quality guidelines, it follows that ambient air quality guidelines would be met at any specific onshore receptor location. For this reason, specific locations of sensitive receptors were not identified at the onset of modeling.

Sources: With regard to source characteristics, point sources were modeled with fixed stack parameters, including physical dimensions and exhaust characteristics. Flares were also modeled as stacks, with adjustments made to account for and maintain thermal buoyancy associated with the high temperature of the flare. All of the emissions sources on the FPSO were conservatively modeled at a single location on the FPSO (representing the highest predicted ambient air concentration scenario). Area sources (i.e., mobile sources without fixed locations) were modeled in a fashion to represent their transit across planned travel areas. For example, support vessels and helicopters were assumed to operate and generate emissions within the PDA and also to transit between Georgetown and the PDA. There is a potential that additional support vessels for some stages of the Project may transit between Trinidad and Tobago and the PDA; however, based on the low level of emissions contributed by support vessel/helicopter traffic, relative to emissions from non-area sources in the PDA, and the expectation that most support vessel/helicopter traffic will originate from Guyana shorebase facilities, modeling of support vessel area sources assumed that all vessels will transit between Guyana and the PDA.

Figure 6.1-2 shows the modeling domain used in this analysis, the locations of the main Project point sources (the FPSO and the drillships supporting the Project), and the boundary of Project-related area sources (including support vessels, installation vessels, and other sources without a fixed location), as configured for the modeling. The figure also shows the locations of other (non-Project) EEPGL-related air pollutant emissions sources that were used for modeling of cumulative impacts, as described in Chapter 10, Cumulative Impact Assessment.

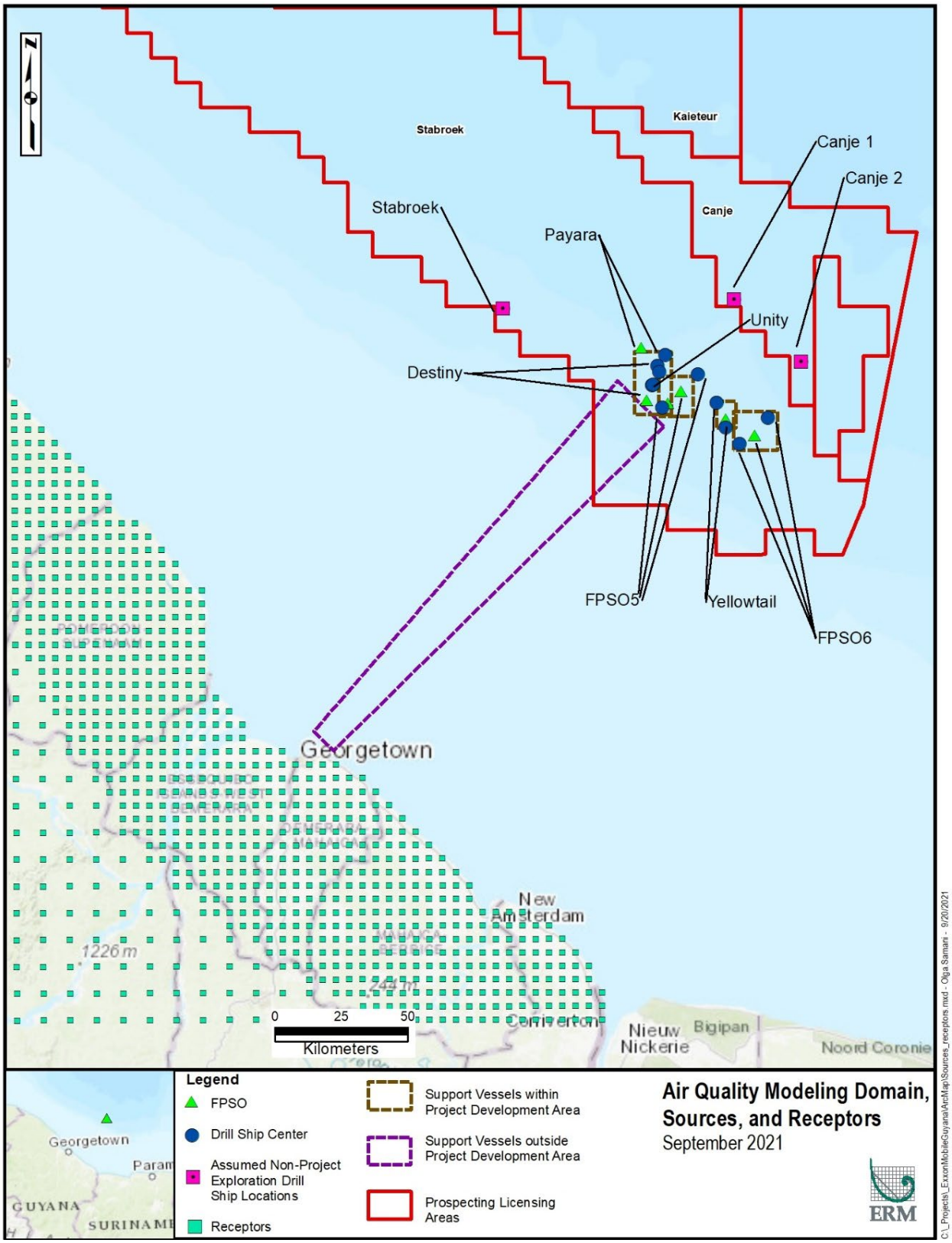


Figure 6.1-2: Air Quality Modeling Domain

Model Selection: The CALPUFF model (Version 7.3.2, level 200113) used in the assessment is a non-steady-state model used in the United States and around the globe for long-range transport and complex wind modeling. CALPUFF is a Lagrangian "puff" model that treats a plume of emissions as a series of puffs that it tracks as the wind carries the plume toward potential receptor locations. The selection of CALPUFF was based on the relatively large distance between the PDA and the potential onshore receptors. The distance from the PDA to the coastline of Georgetown is approximately 203 kilometers (126 miles). At this distance, emission plumes released from the point sources in the PDA would travel for approximately 10 hours before reaching the Guyana shoreline, assuming an average wind speed of 5 meters (16.4 feet) per second (typical for the area). During this transport time, winds can change direction and speed. Accordingly, prediction of plume dispersion is most appropriately accomplished with a non-steady state model.

Meteorological Data: The Weather Research and Forecasting (WRF) model (WRF-ARW, Version 4.0) (Skamarock 2019) was used to develop a simulated meteorological data set for the air quality modeling, because there is limited suitable observational data available for the region. The WRF model is a state-of-the-science numerical meteorological model that is designed to simulate atmospheric systems on a wide range of spatial and temporal scales. A full three-dimensional (3D) grid of WRF-simulated meteorological data was used for the CALPUFF simulations. These data include simulated meteorological conditions across the modeling domain at a resolution of 9 kilometers (5.6 miles). Observational data from 2017 through 2019 were used as input for the WRF model. This period was simulated to identify the worst-case dispersion conditions (i.e., leading to the maximum predicted onshore concentrations) that would be expected during the Project life cycle (at least 20 years). The profiles generated by the WRF model were used by CALPUFF to simulate the transport and dispersion of emission plumes from Project sources, allowing the model to calculate ambient constituent concentrations at potential receptor locations, accounting for changes in meteorology as the plumes travel downwind.

Predicted Ambient Air Concentrations

Using the methodology described above, modeling was conducted with CALPUFF to predict maximum onshore ground-level concentrations of each pollutant as a result of emissions from Project sources. As noted above, modeling was performed for the High Case emissions estimates—reflecting the credible worst-case resulting ambient onshore concentrations of pollutants. Model results were developed for each modeled pollutant, for each averaging period with an associated guideline concentration (Table 6.1-2). Results are summarized in Table 6.1-17.

Table 6.1-17: Summary of Modeling Results—Maximum Predicted Project Impact at Onshore Locations

Pollutant	Averaging Period	Ranking	Guideline Concentration (µg/m³) [a]	Maximum Predicted Onshore Concentration (µg/m³) [b]			Percent of Guideline		
				2023–2024	2025–2027	2028–2044	2023–2024	2025–2027	2028–2044
NO_2	1-hour	Max	200	11.96	12.19	10.51	6.0%	6.1%	5.3%
	1-hour	98th percentile	188	3.64	3.39	2.84	1.9%	1.8%	1.5%
	24-hour	99th percentile	25	1.58	1.43	1.30	6.3%	5.7%	5.2%
	Annual	Max	10	0.23	0.26	0.24	2.3%	2.6%	2.4%
SO_2	10-minute	Max	500	0.57	0.93	0.80	0.1%	0.2%	0.2%
	1-hour	99th percentile	196	0.17	0.22	0.18	0.1%	0.1%	0.1%
	24-hour	99th percentile	40	0.05	0.09	0.07	0.1%	0.2%	0.2%
PM_{10}	24-hour	99th percentile	45	0.11	0.13	0.10	0.2%	0.3%	0.2%
	24-hour	Second high	150	0.20	0.20	0.17	0.1%	0.1%	0.1%
	Annual	Max	15	0.02	0.02	0.02	0.1%	0.1%	0.1%
$PM_{2.5}$	24-hour	99th percentile	15	0.11	0.13	0.10	0.7%	0.8%	0.7%
	24-hour	98th percentile	35	0.08	0.10	0.08	0.2%	0.3%	0.2%
	Annual	Max	5	0.02	0.02	0.02	0.4%	0.4%	0.4%
CO	15-minute	Max	100,000	5.24	8.27	6.33	0.01%	0.01%	0.01%
	1-hour	Max	35,000	3.97	6.27	4.80	0.01%	0.02%	0.01%
	1-hour	Second high	40,000	3.82	5.69	4.28	0.01%	0.01%	0.01%
	8-hour	Max	10,000	2.55	2.89	2.32	0.03%	0.03%	0.02%
	8-hour	Second high	10,000	2.34	2.68	2.09	0.02%	0.03%	0.02%
	24-hour	99th percentile	4,000	0.52	1.35	0.98	0.01%	0.03%	0.02%
H_2S	24-hour	Max	150	NA	0.0008	0.0005	NA	0.001%	0.0003%

NA = not applicable; NO_2 = nitrogen dioxide; $PM_{2.5}$ = particulate matter (aerodynamic diameter less than 2.5 microns); PM_{10} = particulate matter (aerodynamic diameter less than 10 microns); SO_2 = sulfur dioxide

[a] WHO 2000; WHO 2005; WHO 2021; USEPA 2021

[b] Concentrations are the maximum predicted onshore concentrations across the modelled meteorological conditions.

[c] NOx to NO_2 conversion for model-predicted concentrations was based on the Tier 2 Ambient Ratio Method, which uses a 0.8 scaling factor for short-term averaging period and 0.75 for annual averaging.

Magnitude of Impact—Air Quality

The magnitude rating for potential air quality impacts is determined on the basis of two factors:

- The increase in pollutant concentrations in air as a result of the Project (Project Contribution [PC]); and
- The total air pollutant concentration arising as a result of the PC added to the existing conditions (the Predicted Environmental Concentration [PEC]).

The PC and PEC are considered in the context of the above-referenced ambient air quality guidelines. The approach taken to assign magnitude ratings is based on guidance from the International Finance Corporation for undegraded airsheds that states: "Emissions [should] not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards. As a general rule, this Guideline suggests 25 percent of the applicable air quality standards to allow additional, future sustainable development in the same airshed." This assessment has developed definitions for the various magnitude levels based on this guidance (see Figure 6.1-3).

Magnitude of Impacts

	Undegraded Airshed (Baseline < AQS)	Degraded Airshed (Baseline >AQS)
Negligible	PC < 25% of AQS	PC <10% of AQS
Small	PC >25% of AQS, <50% of AQS, and PEC <100% of AQS	PC >10% of AQS, <15% of AQS
Medium	PC >25% of AQS, <50% of AQS, and PEC >100% of AQS; or PC >50% of AQS, <100% of AQS, and PEC <100% of AQS	PC >15% of AQS, <25% of AQS
Large	PC >50% of AQS, <100% of AQS, and PEC >100%; or PC >100% of AQS	PC >25% of AQS

AQS = air quality standard (air quality guidelines were used for the AQS in this assessment); undegraded airshed = environmental conditions where measured existing (baseline) concentrations exceed a specific AQS.

Figure 6.1-3: Definitions for Magnitude Ratings for Potential Impacts on Air Quality

Existing onshore air quality in the Georgetown area is discussed in Section 6.1.2.1, Existing Conditions—Air Quality. To support interpretation of the result of air dispersion modeling, the guidelines shown in Table 6.1-2 were used to characterize existing conditions in the ambient airshed. For each of the parameters subjected to modeling and each of the averaging periods for which a guideline is provided in Table 6.1-2, Table 6.1-18 shows the maximum measured concentrations for the same averaging periods. These maximum measured concentrations were developed based on combining the separate monitoring campaigns into a single data set (i.e., combining data from the three ambient air quality monitoring sites). These maximum measured concentrations were used to represent the existing ambient air concentrations where an onshore receptor could potentially be located.

Table 6.1-18: Summary of Maximum Measured Baseline Ambient Air Concentrations

Pollutant	Averaging Period	Maximum Concentration (µg/m^3)	Applicable Guideline (µg/m^3)
Nitrogen dioxide (NO_2)	1-hour	40.8[j] / 24.1[a]	200[j] / 188[a]
	24-hour	9.4	25[b]
	Full Period (318 days)	1.1	10[f]
Sulfur dioxide (SO_2)	10-minute	38.7	500[h]
	1-hour	18.9	196[c]
	24-hour	4.7	40[b]
Particulate matter (PM_{10})	24-Hour	154.3[b] / 140.4[g]	45[b] / 150[g]
	Full Period (320 days)	25.9	15[f]
Particulate matter ($PM_{2.5}$)	24-Hour	53.1[b] / 21.6[d]	15[b] / 35[d]
	Full Period (320 days)	9.6	5[f]
Carbon monoxide (CO)	15-minute	2,767	100,000[i]
	1-hour	1,660[n]/1,562[k]	35,000[j]/40,000[k]
	8-hour	1,316[n]/1,156[m]	10,000[l]/10,000[m]
	24-hour	905	4,000[b]
Hydrogen sulfide (H_2S)	24-hour	22.3	150[o]

[a] Average of the 98th percentile 1-hour average concentrations for each of the modeled years.
[b] Maximum of the 99th percentile 24-hour average concentrations across all modeled years.
[c] Average of the 99th percentile 1-hour average concentrations for each of the modeled years.
[d] Average of the 98th percentile 24-hour average concentrations for each of the modeled years.
[e] Average of the annual average concentrations for each of the modeled years.
[f] Maximum of the annual average concentrations across all modeled years.
[g] Maximum of the second-highest 24-hour average concentrations across all modeled years.
[h] Maximum of the 10-minute average concentrations across all modeled years.
[i] Maximum of the 15-minute average concentrations across all modeled years.
[j] Maximum of the highest 1-hour average concentrations across all modeled years.
[k] Maximum of the second-highest 1-hour average concentrations across all modeled years.
[l] Maximum of the highest 1-hour average concentrations across all modeled years.
[m] Maximum of the second-highest 1-hour average concentrations across all modeled years.
[n] First highest was used as the background concentration for 1-hour and 8-hour CO.
[o] Maximum of the 24-hour average concentrations across all modeled years.

Based on the fact that the maximum measured onshore ambient PM_{10}, and $PM_{2.5}$ concentrations exceeded ambient air quality guidelines for these parameters, the onshore airshed in the Georgetown area was considered a degraded airshed for PM and an undegraded airshed for other constituents.

As shown in Table 6.1-17, the maximum onshore concentrations predicted to result from planned Project activities for all modeled averaging periods are all 0.8 percent or less of the respective ambient air quality guidelines for PM_{10}, and $PM_{2.5}$, and are all 6.3 percent or less of the respective ambient air quality guidelines for other pollutants. Accordingly, following the definitions in Figure 6.1-3, the magnitude of potential Project impacts on air quality is considered **Negligible**.

Sensitivity of Receptors—Air Quality

The standard approach taken in air quality impact assessment assumes that the sensitivity to air pollutant-related health impacts for receptors within the general population is **Medium**. This is on the basis that, as air quality standards are set to protect the most vulnerable individuals in society, there is inherently a margin of safety within air quality standards. There are a small number of specific cases where receptor sensitivity may be defined as **High**; these cases include where there are particularly vulnerable individuals (e.g., a hospital where there are intensive care wards and high-dependency wards where patients will be particularly sensitive to air pollution).

As such, the sensitivity of most potential onshore receptors is considered **Medium**, with the potential for some receptors to have a **High** sensitivity.

Impact Significance—Air Quality

Based on the magnitude of impact and receptor sensitivity ratings, the significance of potential impacts on air quality for all receptors is **Negligible**.

6.1.3.4. Characterization of Potential Impacts—Climate / Climate Change

Potential climate / climate change impacts are a global concern and stem from cumulative worldwide GHG concentrations. The Global Circulation Models used to predict climate impacts from global concentrations are built around emissions on a global scale, and thus are not capable of modeling impacts from the GHG emissions contribution from a single project such as the Yellowtail Development Project. Statistical downscaling methods can be used to establish a statistical relationship between global climate and local climate using observed data, and can be used to estimate future local climate changes based on the results of Global Circulation Models. However, the reverse approach of predicting the impact of local GHG emissions on global (or local) climate change is not feasible due to the multiple factors—beyond that of a single project—that drive global climate change predictions. For these reasons, while it is possible to quantify the total GHG emissions from the Project, it is difficult to assign a magnitude rating that reflects the potential effects the resource will experience specifically as a result of the Project (as is done for other resources assessed in this EIA). Recognizing this limitation, this EIA provides a rating for what is referred to herein as *impact significance*. The assessment of

potential impact significance for the Project's impacts on global climate / climate change is conducted differently from the assessment for other resources.

The approach taken is to assign a significance rating for potential Project GHG emissions, as a proxy for impacts on global climate change, based on the following factors:

- Comparison of Project GHG emissions to those of Guyana (i.e., without the Project) and to regional and global GHG emissions; and
- Comparison of Project GHG emissions to those of the global oil and gas industry.

As discussed above in relation to air quality, it is EEPGL's policy to avoid routine flaring of associated gas. This represents a significant reduction in annual Project emissions compared to the emissions that would result from the Project conducting routine flaring. Additionally, the Project design includes a series of embedded controls that serve to further reduce emissions of atmospheric pollutants (see Table 6.1-14). Many of these embedded controls also serve to decrease GHG emissions.

Table 6.1-19 summarizes the estimated annual GHG emissions that would be associated with the Project if routine flaring were employed and if none of the above-listed embedded controls were adopted. Table 6.1-19 then summarizes the reductions in GHG emissions resulting from avoidance of routine flaring and the additional reductions in GHG emissions resulting from adoption of the listed embedded controls.

Table 6.1-19: Estimated Annual Project GHG Emissions (Pre-Mitigation)

	Design Case			Modeled Case		
	Estimated Annual GHG Emissions (kilotonnes CO_2e) [a]			Estimated Annual GHG Emissions (kilotonnes CO_2e) [a]		
	2024 (peak of 2023-2024)	2026 (peak of 2025-2027)	Average of 2028-2044	2024 (peak of 2023-2024)	2026 (peak of 2025-2027)	Average of 2028-2044
All Project Activities (combined)—no avoidance of routine flaring, no embedded controls, and no mitigation measures considered	240	5,768	6,755	240	5,798	7,040
Reduction due to avoidance of routine flaring	—	3,064	5,088	—	3,064	5,088
	—	53%	75%	—	53%	73%
All Project Activities (combined)—considering avoidance of routine flaring, but not considering embedded controls	240	2,704	1,667	240	2,734	1,952
Additional reduction due to embedded controls	—	766	339	—	766	339
	—	28%	20%	—	28%	17%
All Project Activities (combined)—considering avoidance of routine flaring and use of embedded controls	240	1,938	1,328	240	1,968	1,613

[a] The annual estimated totals reflect the current preliminary Project schedule (see Section 2.2, Project Schedule) and production profile and remains subject to change.

As with the discussion of air pollutant emissions above, Table 6.1-19 provides a summary of expected peak annual GHG emissions from various planned Project activities for each of three time periods: 2023 to 2024 (development well drilling; Subsea, Umbilicals, Risers, and Flowlines [SURF] installation and commissioning; FPSO installation; and operation of related support vessels); 2025 to 2027 (continued development well drilling; operation of related support vessels; FPSO start-up and associated temporary, non-routine flaring; beginning of production operations; and tanker loading); and 2028 to 2044 (production operations following start-up, including temporary, non-routine flaring; potential continued development well drilling; operation of related support vessels; and tanker loading For the first two time periods, the GHG emissions for each time period are all from the same year within the time period (i.e., 2024 and 2026). These are the years with the maximum anticipated annual GHG emissions for any of the years during the respective time periods (considering avoidance of routine flaring, adoption of embedded controls, and adoption of mitigation measures). For the third time period, the GHG emissions are the average annual emissions across the period (considering avoidance of routine flaring, adoption of embedded controls, and adoption of mitigation measures). Table A-7 in Attachment A of Appendix G, Emissions Inventory and Air Quality Modeling Report, provides a detailed breakdown of estimated year-by-year GHG emissions.

The primary sources of GHG emissions are the combustion turbines and flares on the FPSO, with smaller amounts from other fuel combustion sources. GHG emissions were calculated in three parts: the quantity of carbon dioxide (CO_2) in the fuel that is emitted directly as CO_2; products of combustion of various fuel components based on the potential for each component to contribute to GHG emissions; and the CO_2-equivalent (CO_2e) emissions of other emitted compounds such as methane and nitrous oxides. Emission factors from the AP-42 document noted above were used to calculate the combustion-related GHG emissions (USEPA Undated).

As shown in Table 6.1-19, GHG emissions will occur during all three of the time periods considered for atmospheric emissions. In the first time period (characterized by drilling and installation activities), GHG emissions will be relatively low. In the second time period, drilling will still be ongoing, commissioning and start-up will occur, and production operations will begin. In the last time period, production operations will be ongoing, potentially with continued development drilling for up to 5 years. This period has an estimated average annual pre-mitigation GHG emission level of 1,328 kilotonnes of CO_2e emissions per year for the Design Case and 1,613 kilotonnes of CO_2e emissions per year for the Modeled Case; these average annual GHG emission rates during the third time period are the focus for the remainder of this assessment. GHG emissions during the decommissioning stage will be relatively low, comprising emissions principally from decommissioning vessels.

Guyana published its Second National Communication on Climate Change in 2012 (Government of Guyana 2012) and it reported in this communication to be a net sink of GHGs (meaning its national “removals” exceeded its national emissions). This document provided country-level GHG estimates, the most recent of which was for 2004. For 2004, the document states that reported net annual removals for Guyana were approximately 56.9 million tonnes of CO_2e, comprising total removals of approximately 61.5 million tonnes of CO_2e and total

emissions of approximately 4.671 million tonnes of CO_2e. Guyana's most recent submittal to the United Nations Framework Convention on Climate Change (UNFCCC) under the Paris Agreement, titled *Guyana's Revised Intended Nationally Determined Contribution*) (Guyana NDC 2016), states that the most recent GHG inventory for Guyana is still for the year 2004, and comprised aggregate emissions of 4.617 million tonnes CO_2e (excluding removals). Referring to the Second National Communication (which is cited in the Revised Intended Nationally Determined Contribution for this value), the correct value appears to be 4.671 million tonnes CO_2e. Guyana's Office of Climate Change is currently updating the Second National Communication to the United Nations; in a document from the United Nations Development Programme discussing the pending update, an annual emission rate of 4.213 million tonnes of CO_2e is cited for 2016, with the note that this value excludes emissions from the Land-Use, Land Use Change, and Forests category (UNDP 2020).

As a conservative measure, considering only the figures provided in Guyana's submittals to the UNFCCC (i.e., 4.671 million tonnes CO_2e), the overall emissions at a country level would be increased by approximately 28 to 35 percent as a result of pre-mitigation Project GHG emissions; however, net country-level removals would decrease only from 56.9 million tonnes of CO_2e to 55.6 million tonnes of CO_2e for the Design Case (i.e., an approximately 2 percent decrease) and from 56.9 million tonnes of CO_2e to 55.3 million tonnes of CO_2e for the Modeled Case (i.e., an approximately 3 percent decrease).

According to the World Resources Institute (WRI) Climate Analysis Indicators Tool, Guyana emitted 19.12 million tonnes (19,120 kilotonnes) CO_2e in 2018 (WRI Undated_a). Around 74 percent of these emissions (or 14.09 million tonnes CO_2e) were attributable to land-use change and forestry. The total WRI estimate for 2018 excluding Land-Use Change and Forestry is 5,030 kilotonnes CO_2e.

From a regional perspective, the Inter-American Development Bank, in its 2013 publication *The Climate and Development Challenge for Latin America and the Caribbean* (Vergara et al. 2013), projected regional emissions of 6,730 million tonnes per year CO_2e by 2050 for a "business as usual"[5] scenario and 1,450 million tonnes per year for a "GHG target" scenario (which is based on a target of 2 tonnes per capita). Considering these regional estimates, the Project's estimated pre-mitigation average annual GHG emissions during the third time period for the Design Case (1.328 million tonnes per year) represent between 0.02 and 0.09 percent of these projected regional 2050 emissions; the Project's estimated pre-mitigation average annual GHG emissions during the third time period for the Modeled Case (1.613 million tonnes per year) represent between 0.02 and 0.11 percent of these projected regional 2050 emissions.

From a global perspective, the WRI's Climate Watch tool cites a global GHG emission level of 48.93 gigatonnes CO_2e/year for 2018 (WRI Undated_b). The ranges of global GHG emissions modeled by the IPCC to determine the median target global GHG emissions necessary to reach the commonly discussed target scenarios of "Below 1.5°C" (2.7°F) and "Below 2.0°C" (3.6°F) above pre-industrial levels (both based on a 66 percent probability of estimated temperature

[5] The cited "business as usual" is the judgment of the referenced authors, and is not a term used by the IPCC.

outcomes) by the end of the century are 25 and 41 gigatonnes per year CO_2e, respectively, for the year 2030 (UNEP 2019, Table 3.1). Not considering mitigation measures, under the Design Case, the Project will emit an estimated average of 1,328 kilotonnes (i.e., approximately 0.001328 gigatonnes) CO_2e per year during the third time period. This amounts to approximately 0.003 percent of the 2018 baseline emission level and 0.005 to 0.003 percent of the global GHG emissions modeled by the IPCC for the 1.5°C (2.7°F) and 2°C (3.6°F) scenarios, respectively. Not considering mitigation measures, under the Modeled Case, the Project will emit an estimated average of 1,613 kilotonnes (i.e., approximately 0.001613 gigatonnes) CO_2e per year during the third time period. This amounts to approximately 0.003 percent of the 2018 baseline emission level and 0.006 to 0.004 percent of the global GHG emissions modeled by the IPCC for the 1.5°C (2.7°F) and 2°C (3.6°F) scenarios, respectively.

From a GHG intensity standpoint, the average *pre-mitigation* GHG intensity for the Project's production operations activities (considering 2026 through 2044) is 29.5 kilograms of CO_2e per barrel of crude oil for the Design Case and 35.4 kilograms of CO_2e per barrel of crude oil for the Modeled Case. For comparison purposes, a number of studies were researched to provide insight on average values for GHG intensity in the oil and gas production sector. The aggregate GHG intensities (CO_2e per barrel of oil equivalent) outlined in the references below are estimated industry averages. Each study utilized different data, methodologies, models, and assumptions from a broad spectrum of oil and gas assets to generate their estimates. While this variability makes it difficult to make a direct comparison of Project GHG intensity (CO_2e per barrel of oil equivalent) to a composite industry average, the studies do provide points of reference for assessment of the GHG intensity of the Project.

- A Stanford University study published in 2018 states that global oil production in 2015 resulted in 10.3 grams of CO_2e emissions per megajoule of crude oil, which converts to approximately 63 kilograms of CO_2e emissions per barrel of crude oil (Garthwaite 2018).
- The Carnegie Endowment for International Peace's Oil Climate Index has estimated that the GHG intensity for crude oil production operations in Latin America and the Caribbean, including onshore and offshore operations, is 66 kilograms of CO_2e per barrel of crude oil (for upstream emission estimates) (Carnegie Endowment Undated).
- The Oil and Gas Climate Initiative reports that their members had an aggregate GHG intensity of 23 kilograms of CO_2e per barrel of oil equivalent in 2017 (OGCI Undated).
- An S&P Global 2020 report cites a collective upstream methane and GHG intensity of upstream oil and gas operations at 21 kilograms of CO_2e per barrel of oil equivalent for 2019 (Perkins 2020).

Climate change has a high importance as a global concern. The Project represents an increase in GHG emissions, specifically in terms of the percentage increase of national Guyana GHG emissions that the Project's pre-mitigation GHG emissions would represent. However, this is balanced against the relatively small percentage decrease of Guyana's net removals represented by the Project's pre-mitigation GHG emissions. Balancing these factors, a pre-mitigation significance rating of **Moderate** is assigned for the production operations stage.

Based on the relatively low GHG emissions prior to and following cessation of production operations, pre-mitigation significance ratings of **Negligible** are assigned for the drilling; installation, commissioning, and start-up; and decommissioning stages.

6.1.4. Management Measures—Air Quality, Climate, and Climate Change

Based on the **Negligible** significance of potential air quality, no additional mitigation measures are considered warranted. However, a number of embedded controls and mitigation measures technologies incorporated into the Project will aid in reducing emissions of pollutants to the atmosphere (see Tables 6.1-14 and 6.1-15).

In addition to the above-referenced embedded controls—most of which will also serve to mitigate emissions of GHGs—the design elements incorporated as additional mitigation measures to reduce energy consumption (and therefore to reduce GHG emissions) by the Project (see Table 6.1-15) were considered for the purpose of assigning a residual impact significance level for potential impacts on climate.

The residual significance of potential Project impacts on global climate / climate change is assessed on the basis of predicted Project GHG emissions considering the decision to avoid routine flaring, the embedded controls presented in Table 6.1-14, and the additional mitigation measures presented in Table 6.1-15.

As noted above in reference to Table 6.1-19, Table 6.1-20 summarizes the estimated annual residual GHG emissions for the Project (considering avoidance of routine flaring, adoption of embedded controls, and adoption of mitigation measures) for each of three time periods: 2023 to 2024 (development well drilling; SURF installation and commissioning; FPSO installation; and operation of related support vessels); 2025 to 2027 (continued development well drilling; operation of related support vessels; FPSO start-up and associated temporary, non-routine flaring; beginning of production operations; and tanker loading); and 2028 to 2044 (production operations following start-up, including temporary, non-routine flaring; potential continued development well drilling; operation of related support vessels; and tanker loading). For the first two time periods, the GHG emissions for each time period are all from the same year within the time period (i.e., 2024 and 2026). These are the years with the maximum anticipated annual GHG emissions for any of the years during the respective time periods (considering avoidance of routine flaring, adoption of embedded controls, and adoption of mitigation measures). For the third time period, the GHG emissions are the average annual emissions across the period (considering avoidance of routine flaring, adoption of embedded controls, and adoption of mitigation measures). Table A-7 in Attachment A of Appendix G, Emissions Inventory and Air Quality Modeling Report, includes a detailed breakdown of year-by-year GHG emissions.

Table 6.1-21 provides a breakdown of the estimated peak annual GHG emissions—by source—considering avoidance of routine flaring, embedded controls, and mitigation measures.

Table 6.1-20: Estimated Annual Project GHG Emissions (Residual, i.e., with Mitigation Measures)

	Design Case			Modeled Case		
	Estimated Annual GHG Emissions (kilotonnes CO_2e) [a]			Estimated Annual GHG Emissions (kilotonnes CO_2e) [a]		
	2024 (peak of 2023-2024)	**2026 (peak of 2025-2027)**	**Average of 2028-2044**	**2024 (peak of 2023-2024)**	**2026 (peak of 2025-2027)**	**Average of 2028-2044**
All Project Activities (combined)—considering avoidance of routine flaring and embedded controls, but no mitigation measures	240	1,938	1,328	240	1,968	1,613
Additional reduction due to mitigation measures	—	208	218	—	208	218
	—	11%	16%	—	11%	14%
All Project Activities (combined)—considering avoidance of routine flaring, embedded controls, and mitigation measures [b]	240	1,730	1,110	240	1,760	1,395

[a] The annual estimated totals generally reflect the current preliminary Project schedule (see Section 2.2, Project Schedule) and production profile and remains subject to change.
[b] Values rounded up to next multiple of 5 kilotonnes CO_2e

Table 6.1-21: Breakdown of Estimated Annual Project GHG Emissions (Residual, i.e., with Mitigation Measures)

Source Category	Design Case			Modeled Case		
	Estimated Annual GHG Emissions (kilotonnes CO_2e) [a]			Estimated Annual GHG Emissions (kilotonnes CO_2e) [a]		
	2024 (peak of 2023-2024)	2026 (peak of 2025-2027)	Average of 2028-2044	2024 (peak of 2023-2024)	2026 (peak of 2025-2027)	Average of 2028-2044
FPSO Other [b]	0	468	685	0	468	685
FPSO Tanks (venting)	0	35	19	0	35	19
FPSO Flaring (temporary, non-routine)	0	1,103	336	0	1,132	620
Tanker Loading	0	17	9	0	17	9
Area Sources	129	49	43	129	49	43
Drill Ships	109	56	15	109	56	15
Total [c]	240	1,730	1,110	240	1,760	1,395

[a] The annual estimated totals generally reflect the current preliminary Project schedule (see Section 2.2, Project Schedule), which could change.
[b] Includes combustion turbine emissions and diesel engine emissions
[c] Values rounded up to next multiple of 5 kilotonnes CO_2e

Table 6.1-22 below summarizes the comparison of the estimated post-mitigation Project average annual GHG emissions during the production operations stage to the other emission levels discussed above.

Table 6.1-22: Comparison of Estimated Post-Mitigation Project Average Annual Production Operations GHG Emissions to Guyana, Latin America and Caribbean Region, and Global Emissions

	GHG Emissions (million tonnes CO_2e/year)	**Percent Represented by Yellowtail Project Average Annual Emissions during Production Operations Stage**
Yellowtail Project Average Annual Emissions during Production Operations Stage	1.110 (Design Case) 1.395 (Modeled Case)	—
Most recent Nationally Determined Contribution estimate of Guyana's GHG Emissions (2004)[a]	4.671	23.8% (Design Case) 29.8% (Modeled Case)
Most recent Nationally Determined Contribution estimate of Guyana's Net GHG Removals (2004)	56.9	2.0% (Design Case) 2.5% (Modeled Case)
Most recent WRI estimate of Guyana's GHG Emissions (2018) [b]	19.12	5.8% (Design Case) 7.3% (Modeled Case)
Latin America and Caribbean [c] Business As Usual Projection [d] by 2050	6,730	0.02% (Design Case) 0.02% (Modeled Case)
Latin America and Caribbean GHG Target [f] by 2050 [e]	1,450	0.08% (Design Case) 0.10% (Modeled Case)
Global Emissions in 2018 [g]	48,930	0.002% (Design Case) 0.003% (Modeled Case)
Global Emissions (1.5°C and 2°C scenarios; by 2030) [h]	25,000 to 41,000	0.004% to 0.003% (Design Case) 0.006% to 0.003% (Modeled Case)

[a] Government of Guyana 2012
[b] WRI Undated_a
[c] Latin America and Caribbean includes the following countries: Argentina, Bahamas, Bolivia, Brazil, Cuba, Chile, Colombia, Ecuador, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Peru, Suriname, Venezuela.
[d] Business as Usual" projection in 2050 (i.e., trajectory if certain mitigations and controls are not enacted)
[e] Vergara et al. 2013
[f] The Latin America and Caribbean GHG target is 2 tonnes per capita, which converts to roughly 1.45 gigatonnes CO2e.
[g] WRI Undated_b
[h] UNEP 2019, Table 3.1

With the incorporation of mitigation measures, the estimated post-mitigation GHG intensity for the Project's production operations activities (considering 2026 through 2044) drops to 24.7 kilograms of CO_2e per barrel of crude oil for the Design Case and to 30.6 kilograms of CO_2e per barrel of crude oil for the Modeled Case. For comparison purposes, Table 6.1-23 provides a summary of the GHG intensity information reported in the above-referenced studies regarding the oil and gas production sector.

Table 6.1-23: Comparison of Estimated Post-Mitigation Project GHG Intensity to Average Carbon Intensities from Oil and Gas Production Sector Studies

	GHG emissions intensity (kilograms CO_2e per Barrel of Crude Oil)	**Reference**
Global Average (2015 data)	63	Stanford University
Regional Average (Latin America and Caribbean)	66	Carnegie Endowment for International Peace
Global Average (Upstream) (2017 data)	23	Oil and Gas Climate Initiative
Global Average (Upstream) (2019 data)	21	S&P Global
Yellowtail Project (post-mitigation average; 2026-2044)	24.7 (Design Case) 30.6 (Modeled Case)	EEPGL

For comparison, the estimated GHG intensities at the time of EIA preparation for the Liza Phase 1, Liza Phase 2, and Payara projects were 37.0, 25.3, and 27.5 kilograms CO_2e per barrel of crude oil, respectively. These values were based on the preliminary design, schedule, and production profiles of these projects at the time, and do not necessarily reflect the estimated intensities based on finalization of designs and schedules. Due to additional design redundancy in the processing units, Yellowtail reliability and gas processing performance is expected to improve compared to the other FPSOs. However, the predicted production profiles and reservoir performance indicate that hydrocarbon (oil and gas) production and processing demands will be higher than from previous projects. This is driven by the hydrocarbon compositions, volumes, and deliverability naturally present in the reservoir. Thus, estimated flaring volumes are higher than EIA estimations from previous projects, despite improvements in design for reliability.

Adoption of the stated mitigation measures will further decrease that already substantial decrease in Project GHG emissions resulting from avoidance of routine flaring and incorporation of the stated embedded controls, but the Project still represents an increase of national Guyana GHG emissions. The mitigated emissions represent a relatively small percentage decrease of Guyana's net removals. The Project has applied technologies aligned with good international oil field practice to reduce GHG emissions; this suggests that it is appropriate to reduce the significance rating. However, in view of the fact that climate change is an issue of global importance, the significance rating of **Moderate** is maintained for the production operations stage.

Consistent with good international oil field practice, EEPGL will annually quantify direct Project GHG emissions from the dedicated Project facilities and equipment used within the Project AOI (World Bank 2015). Additionally, each year, as part of its annual planning process, EEPGL will review these quantified GHG emissions and establish plans to achieve continuous improvement.

Table 6.1-24 summarizes the monitoring measures relevant to this resource.

Table 6.1-24: List of Monitoring Measures

Monitoring Measures
Monitor on an ongoing basis the volume of fuel used by all combustion sources and equipment on FPSO and other marine vessels.
Monitor volume of fuel used for helicopter operation.
Keep records of non-routine flaring of associated gas.
An air emissions inventory report will be prepared annually.
Monitor flare performance to maximize efficiency of flaring operation.

Based on published corporate plans, EEPGL and its affiliates support the goals of the 2015 Paris Agreement and efforts of global Nationally Determined Contributions to achieve net-zero emissions, and have made meaningful progress, globally, in reducing GHG emissions. In this regard, ExxonMobil affiliates are reported to be on track, collectively, to meet the 2025 GHG emission-reduction plans announced by ExxonMobil in December 2020, and ExxonMobil anticipates year-end 2021 results to show a reduction of 15 to 20 percent in GHG intensity from its upstream operations, as compared to 2016 levels—4 years ahead of schedule. This is supported by an anticipated reduction of 40 to 50 percent in methane intensity and 35 to 45 percent in flaring intensity compared to 2016. ExxonMobil's recently announced GHG reduction plans for 2030 are consistent with Paris Agreement-aligned pathways and include reductions in Scope 1 and Scope 2 GHG emissions from assets operated by ExxonMobil affiliates by the end of 2030, as compared to 2016 levels. ExxonMobil has also reaffirmed plans to achieve the goals of the World Bank for Zero Routine Flaring by 2030 (ExxonMobil 2021).

Table 6.1-25 summarizes the assessment of potential pre-mitigation and residual Project impacts on air quality and climate. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the air quality-specific methodology described in Sections 6.1.3.2, Emissions of Air Quality Pollutants, and 6.1.3.3, Characterization of Impacts—Air Quality.

Table 6.1-25: Summary of Potential Pre-Mitigation and Residual Impacts—Air Quality, Climate, and Climate Change

Stage	Resource/Receptor—Impact	Magnitude Rating	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project Stages	Ambient air quality—increased concentrations of pollutants in ambient air, potentially contributing to health impacts for onshore human receptors	Negligible	Medium (most of population) High (more sensitive receptors)	Negligible	Embedded controls listed in Table 6.1-14 and mitigation measures listed in Table 6.1-15	Negligible
Development Drilling Installation, Commissioning, and Start-up Decommissioning	Climate—GHG emissions, resulting in increases in Guyana's national GHG emissions	—	—	Negligible	Embedded controls listed in Table 6.1-14 and additional mitigation measures listed in Table 6.1-15	Negligible
Production Operations	Climate—GHG emissions, resulting in increases in Guyana's national GHG emissions	—	—	Moderate	Embedded controls listed in Table 6.1-14 and additional mitigation measures listed in Table 6.1-15	Moderate

6.2. SOUND

This section describes the approach to assessment of the potential impacts of sound produced from Project-related activities. Two types of sound are discussed:

- Airborne sound; and
- Underwater sound.

Airborne sound from the Project's offshore activities has the potential to affect seabirds and human receptors in the vicinity of the sound sources. Potential impacts of Project sound on seabirds are discussed in Section 7.4.3, Impact Assessment—Seabirds. Exposure of workers to Project-related sound will be managed under the Project's occupational health and safety program. Workers will be provided with appropriate personal protective equipment, including ear protection (when engineered controls must be augmented to manage sound exposure). Since the PDA is approximately 203 kilometers (126 miles) from shore—where other potential (non-worker) human receptors to airborne sound will be located—sound from the Project's offshore operations would be imperceptible by these potential receptors. Accordingly, this potential impact is not discussed further in this section. With respect to sound generated from onshore activities, the Project is not expected to result in significant changes to existing sound levels at the shorebases, pipe yards, and warehouse locations to be used by the Project, as such facilities already have existing industrial operations. The owners/operators of these facilities will be responsible for managing sound levels from their facilities so as to not cause exceedances of applicable levels. Therefore, potential impacts of airborne sound at these facilities are not discussed further in this section.

The potential impacts of underwater sound from the Project are relevant to marine fauna with the potential to be present in the PDA and surrounding areas. Accordingly, the remainder of this section discusses the assessment of potential impacts of Project-related underwater sound on these receptors.

6.2.1. Administrative Framework—Sound

Table 6.2-1 summarizes the Guyana legislation, policies, or treaty commitments that are relevant to Project-generated sound. Note that the listed Guyanese legislation is applicable to airborne sound, but is included below for completeness. The Joint Nature Conservation Committee (JNCC) guidelines are relevant to management of impacts of underwater sound on marine fauna, the assessment of which is presented in separate sections of the EIA.

Table 6.2-1: Legislation, Policies, or Treaty Commitments—Sound

Title	Objective	Relevance to the Project
Legislation and Standards		
Environmental Protection Noise Management Regulations, 2000	Establishes general provisions for noise avoidance and restrictions from multiple commercial and industrial sources, including sound-making devices, equipment, tools, and construction activities, and includes permitting and reporting requirements. Authorizes EPA to set specific permissible noise levels in the future.	Regulated facilities include any offshore installation and any other installation, whether floating or resting on the seabed.
Guyana Standard, Guidelines for Noise Emission into the Environment, 2010	Establishes standard used for monitoring of noise emission into the environment; sets permissible noise levels for residential, commercial, industrial, institutional, educational, construction, transportation, and recreational receptors (day and night).	Relevant to Project-related noise levels that could be perceived by human receptors (onshore or nearshore activities)
Guidance		
Joint Nature Conservation Committee Guidelines for Minimising the Risk of Injury and Disturbance to Marine Mammals from Seismic Surveys (JNCC 2017)	Provides guidelines for procedures to reduce the risk of injury to marine mammals from geophysical survey activities.	Although the JNCC guidelines are voluntary, they are widely recognized as a global best practice in the oil and gas industry for managing the potential adverse effects of seismic surveys on marine mammals, and will be applicable to vertical seismic profiles conducted on any of the development wells.

6.2.2. Existing Conditions—Underwater Sound

This section includes a summary of the desktop review of existing underwater sound conditions that could be expected in the PDA. It also describes the different metrics commonly used to represent underwater acoustic fields.

6.2.2.1. Underwater Acoustic Metrics

Underwater sound amplitude is measured in decibels (dB) relative to a fixed reference pressure (p_0 = 1 micro Pascal [µPa])[1] or reference energy level (1 μPa^2•s). The following are three common acoustic metrics used to characterize underwater sound levels:

- Peak Sound Pressure Level (PK, measured in dB re 1 µPa)
- Root Mean Square Sound Pressure Level (SPLrms, measured in dB re 1 µPa)
- Sound Exposure Level (SEL, measured in dB re 1 μPa^2•s)

The PK metric is the maximum instantaneous SPL in a stated frequency band attained by an acoustic event. This peak metric is commonly used to characterize impulsive sounds, but does not describe the duration or bandwidth of the sound. At higher intensities, the peak SPL can be a valid criterion for assessing whether a sound may have the potential to result in auditory injury impacts on a marine receptor.

The Root Mean Square SPL (SPLrms) is a measure of the average pressure or the "effective pressure" over the duration of an acoustic event, such as the emission of one acoustic pulse from a seismic source (e.g., vertical seismic profiler). SPLrms is often used to assess whether an acoustic event may have the potential to result in behavioral disturbance on a marine receptor.

The SEL is a measure of the total acoustic energy contained in one or more acoustic events and is often used as an indication of the sound energy dose over a specific event or time period. The SEL metric measures the total sound energy to which a receptor would be exposed over the associated period of time, and can be used to assess the potential for auditory injury impacts. When assessing the potential for auditory damage using the SEL metric, the predicted sound levels are frequency-weighted to mirror the expected hearing ability of a receptor across the frequency range.

More information on the underwater acoustic metrics described above, including the analytical formulation of these metrics, is provided in the document Underwater Sound Associated with Yellowtail Project Activities, prepared by JASCO Applied Sciences, included as Appendix H, Underwater Sound Modeling Report, to this EIA.

6.2.2.2. Characterizing Existing Conditions in the PDA

The ambient underwater sound environment in the PDA has been characterized based on a literature review of open ocean settings.

Sound in the ocean is the result of both natural and anthropogenic sources. Natural contributions include sources such as wind-driven waves, rainfall, and bio-acoustic sound

[1] Sound levels expressed in dB in water are not the same as sound levels expressed in dB in air due to differences in the reference level and impedance of the two media. In underwater acoustics, the standard unit of acoustic pressure is the micro Pascal (µPa), or one-millionth of a Pascal. Therefore, the amplitude of acoustic pressure is compared to 1 µPa so that the sound pressure level (SPL) is defined as SPL = 20*log10(Ap/1 µPa) where Ap is the pressure amplitude determined in a specified way (e.g., peak amplitude, root mean square amplitude). The units of SPL are "dB re 1 µPa," referring to the relative amplitude of a sound wave to a reference pressure of 1 µPa (the reference level for sounds in water) (Bradley and Stern 2008).

generation (e.g., marine fauna vocalizations). A generalized model for deep-water ocean ambient sound was presented by Hildebrand (2009) and characterizes ambient sound levels at a depth of 1,000 meters, taking into account natural sources of sound (e.g., wind, sea state) as well as what the author characterized as “modern shipping noise.” Hildebrand (2009) reported that low-frequency sound (10 to 500 hertz [Hz]) was dominated by commercial shipping and industrial activities such as drilling and seismic exploration and these low frequency sounds have low attenuation and therefore propagate over large distances and across ocean basins. Medium-frequency sound (500 Hz to 25 kilohertz [kHz]) from waves, wind, rainfall, bio-acoustic sound generation, and small vessels and survey sonars has greater attenuation—so does not propagate over large distances (usually within tens of kilometers from the sources). The model predicted ambient sound ranging across the frequency spectrum from about 20 Hz to more than 70 kHz, with sound levels decreasing from a high of approximately 60 to 80 dB re 1 $\mu Pa^2\,Hz^{-1}$ (at 20 Hz), to less than 20 dB re 1 $\mu Pa^2\,Hz^{-1}$ (at 70 kHz). A more recent empirical modeling analysis relating wind speed to 1 kHz spectrum noise in a 1,000-meter (3,281-foot) deep environment had similar results, estimating sound levels from 60.7 dB re 1 μPa^2 Hz-1 at Beaufort Force 4 (5.5 to 7.9 meters [18 to 26 feet] per second) to 69.9 dB re 1 μPa^2 Hz-1 at Beaufort Force 7 (13.9 to 17.1 meters [456 to 56 feet] per second) (Hildebrand et al. 2021), These wind speeds are within the range of wind speeds observed offshore Guyana (see Appendix F, Onshore and Offshore Meteorological Data), and the sounds levels are within the range predicted by Hildebrand’s earlier generalized model (Hildebrand 2009). Noise levels from all sources are generally higher at the low frequency end of the frequency spectrum (Hildebrand 2009).

Observed ambient sound levels have tended to be higher than those predicted by Hildebrand’s modeling analyses. Sound recordings at five sites in the U.S. Exclusive Economic Zone revealed daily average sound pressure levels ranging from approximately 81 to 120 dB re 1 μPa^2 Hz-1 (in a one-third octave band centered on 125 Hz) and from approximately 84 to 133 dB re 1 μPa^2 Hz-1 (in a one-third octave band centered on 63 Hz) (Haver et al. 2020). Of the sites recorded, the Gulf of Mexico site exhibited the loudest ambient sound levels. Sound levels were higher at the sites near cargo vessel activity compared to sites with little to no cargo vessel activity (Haver et al. 2021). Another study in the Gulf of Mexico reported daily average sound pressure levels of over 90 dB re 1 μPa^2 Hz-1 (at less than 40 Hz), which those authors attributed to seismic exploration airguns, although a shallower site in a less-active location exhibited sound pressure levels of less than 55 dB re 1 μPa^2 Hz-1 (at greater than 700 Hz) (Wiggins et al. 2016).

With the exception of localized or short-term events that may result in rises in sound levels (e.g., passage of a ship, intense rain events, whale vocalizations) underwater sound levels do not vary over time at a particular location in the ocean because distant shipping tends to dominate the noise levels (MacDonald et al. 2008; University of Rhode Island and Inner Space Center Undated). Non-Project-related human activities are currently minimal in the PDA (principally related to commercial fishing and transit of other ocean-going vessels). Therefore, it is likely that distant shipping dominates existing sound conditions in the PDA. Other than the ongoing EEPGL exploration activities, the development well drilling, installation, and operations

for EEPGL's previously authorized development projects, and sporadic transits of commercial fishing vessels and other ocean-going vessels in the vicinity of the PDA, there are currently no other sources of mechanical or human-generated underwater sound affecting the PDA.

It is noted that the noise criteria used in the assessment of potential impacts to marine fauna (covered in other sections, as discussed below) do not need to factor the relatively low existing ambient sound levels discussed above, as the criteria associated with potential acoustic injury to marine fauna are much higher than these existing ambient sound levels[1]. Therefore, detailed, site-specific characterization of background ambient sound levels is not necessary to assess potential underwater noise impacts to marine fauna.

6.2.3. Impact Assessment—Underwater Sound

Potential impacts from Project-related underwater sound are discussed in the sections relating to potential impacts on marine life receptors (Sections 7.5.3, Impact Assessment—Marine Mammals; 7.7.3, Impact Assessment—Marine Turtles; and 7.8.3, Impact Assessment—Marine Fish).

6.2.4. Management Measures—Underwater Sound

Management measures to address potential impacts from Project-related underwater sound are discussed in the sections relating to potential impacts on marine life receptors (Sections 7.5.4, Mitigation Measures—Marine Mammals; 7.7.4, Mitigation Measures—Marine Turtles; and 7.8.4, Mitigation Measures—Marine Fish).

6.3. MARINE GEOLOGY AND SEDIMENTS

6.3.1. Administrative Framework—Marine Geology and Sediments

The Consultants have not identified any legislation, policies, or treaty commitments that focus specifically on marine geology and sediments.

6.3.2. Existing Conditions—Marine Geology and Sediments

6.3.2.1. Coastal Geology

Guyana's continental shelf occupies an area of 48,665 square kilometers (km^2) (18,790 square miles [mi^2]). The average width of the continental shelf is approximately 113 kilometers (approximately 70 miles) (NDS 1997). The shelf is widest near the borders of Suriname and Venezuela, and slightly narrower near the center of Guyana's coastline. Guyana's coastline is approximately 432 kilometers (approximately 268 miles) long (NDS 1997). The Guyana coast is a sedimentary plain that has formed from successive deposits of alluvial sediment with a series of coastal ridges crossing the coast from east to west. The alluvial sediments are primarily clays swept out to sea by the Amazon River, carried north by ocean currents, and deposited on

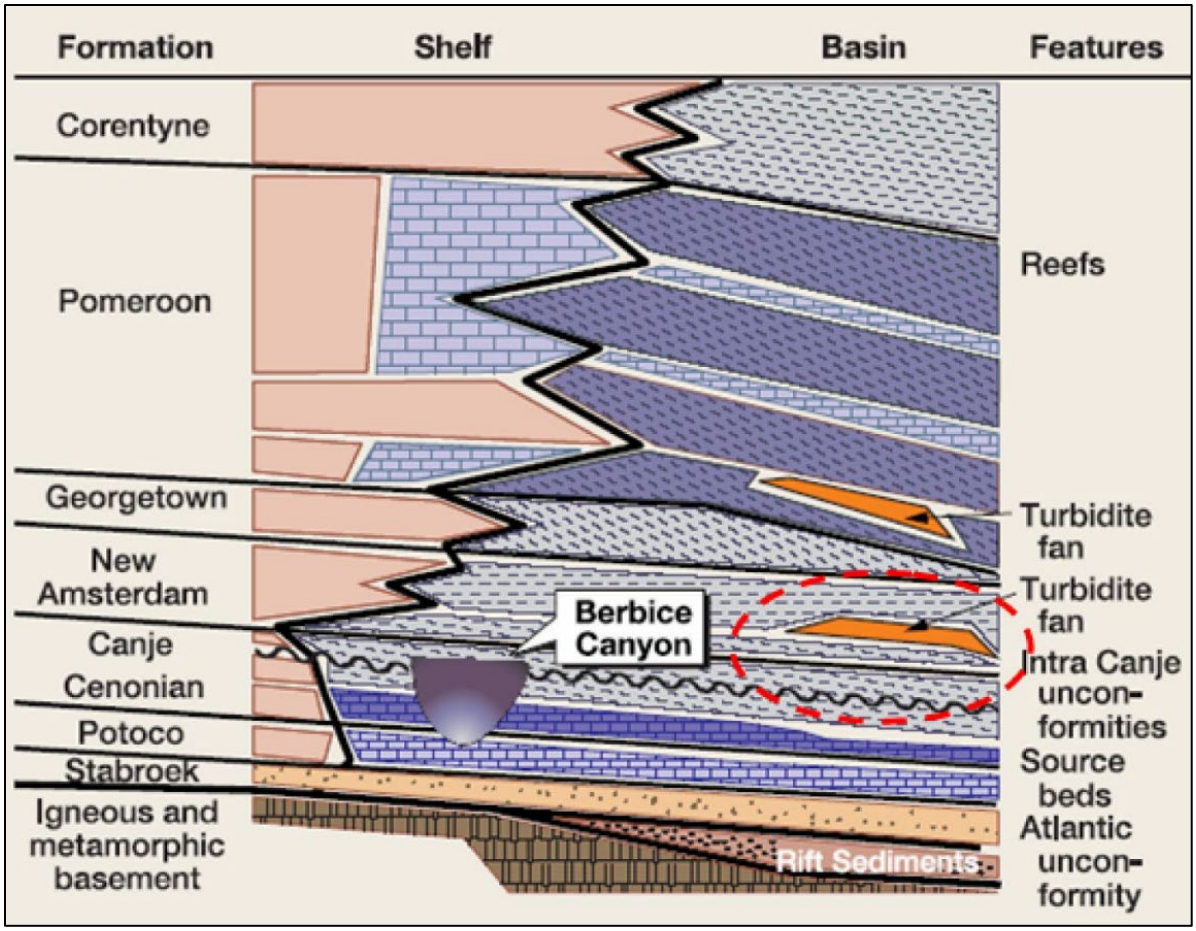
[1] As described in Section 7.5, Marine Mammals, acoustic injury threshold criteria are on the order of 187 to 215 dB. Sound levels add logarithmically, so adding (for example) a 185 dB sound to an 80 dB ambient background would result in a total sound level of 185 dB.

Guyanese shores. The coastal ridges are connected with submarine features that move across the shallow continental shelf in a northward direction, driven by the nearshore current.

6.3.2.2. Marine Stratigraphy

The Guyana Basin has been described as a passive margin basin[1] associated with the rifting and opening of the equatorial Atlantic Ocean. Part of the Guyana Basin is onshore, but most of it occurs offshore. Figure 6.3-1 depicts the basin stratigraphy and Table 6.3-1 summarizes the age and composition of the major geologic formations (listed in descending order from ground surface) that comprise the Guyana Basin (Workman 2000; CGX 2009). The Stabroek formation is Cretaceous-Barremian in age and is dominated by continental shales and sands. Overlying the Stabroek is the Aptian-aged Potoco formation, which is dominated by carbonates. The Santonian- to Turonian-aged interval contains the Canje formation, which is dominated by shales and sandstones. Similarly, the Lower Tertiary to Maastrichtian formation contains the New Amsterdam and Georgetown formations, dominated by sandstones, shales, and carbonates. The Pomeroon and Corentyne formations are of Pleistocene-Pliocene and Miocene-Eocene age and are also dominated by shales and sandstones.

[1] A passive margin is an area where continents have drifted apart to become separated by an ocean. Passive margins are found at every ocean and continent boundary that is not marked by a strike-slip fault or a subduction zone.



Source: From Workman and Birnie 2015; modified by the Consultants

Figure 6.3-1: Stratigraphic Chart of Guyana Basin

Table 6.3-1: Major Geologic Formations of the Guyana Basin

Formation	Age	Composition
Corentyne	Pleistocene-Pliocene	Sandstone and shale
Pomeroon	Miocene-Eocene	Carbonate sandstone and shale
Georgetown	Maastrichtian	Sandstone, shale and carbonate
New Amsterdam	Lower Tertiary to Maastrichtian	Sandstone and shale
Canje and Cenonian	Santonian to Turonian	Organic shale, non-organic shale, and sandstone
Potoco Formation	Aptian	Carbonates
Stabroek Formation	Cretaceous–Barremian	Basal shales and sandstones of continental origin
Precambrian Basement	Proterozoic-Hadean	Igneous/Metamorphic rocks [a]

[a] The igneous/metamorphic basement in Figure 6.3-1 is of Precambrian age.

Previous geophysical studies conducted in the vicinity of the Paraya PDA indicated the presence of numerous anomalous seabed features, referred to in those studies as hard seafloor features (HSFs). These HSFs are understood to be fluid expulsion features resulting from

dewatering and/or degassing of buried turbidites[1] and mass transport deposits[2]. Geophysical survey work conducted in the vicinity of the Yellowtail PDA identified similar HSFs in the geophysical survey area but not within the Yellowtail PDA (see Figure 6.3-2). Accordingly, these HSFs are not discussed further in this section as there are no reasonably foreseeable pathways for potential impacts on these features from planned Project activities.

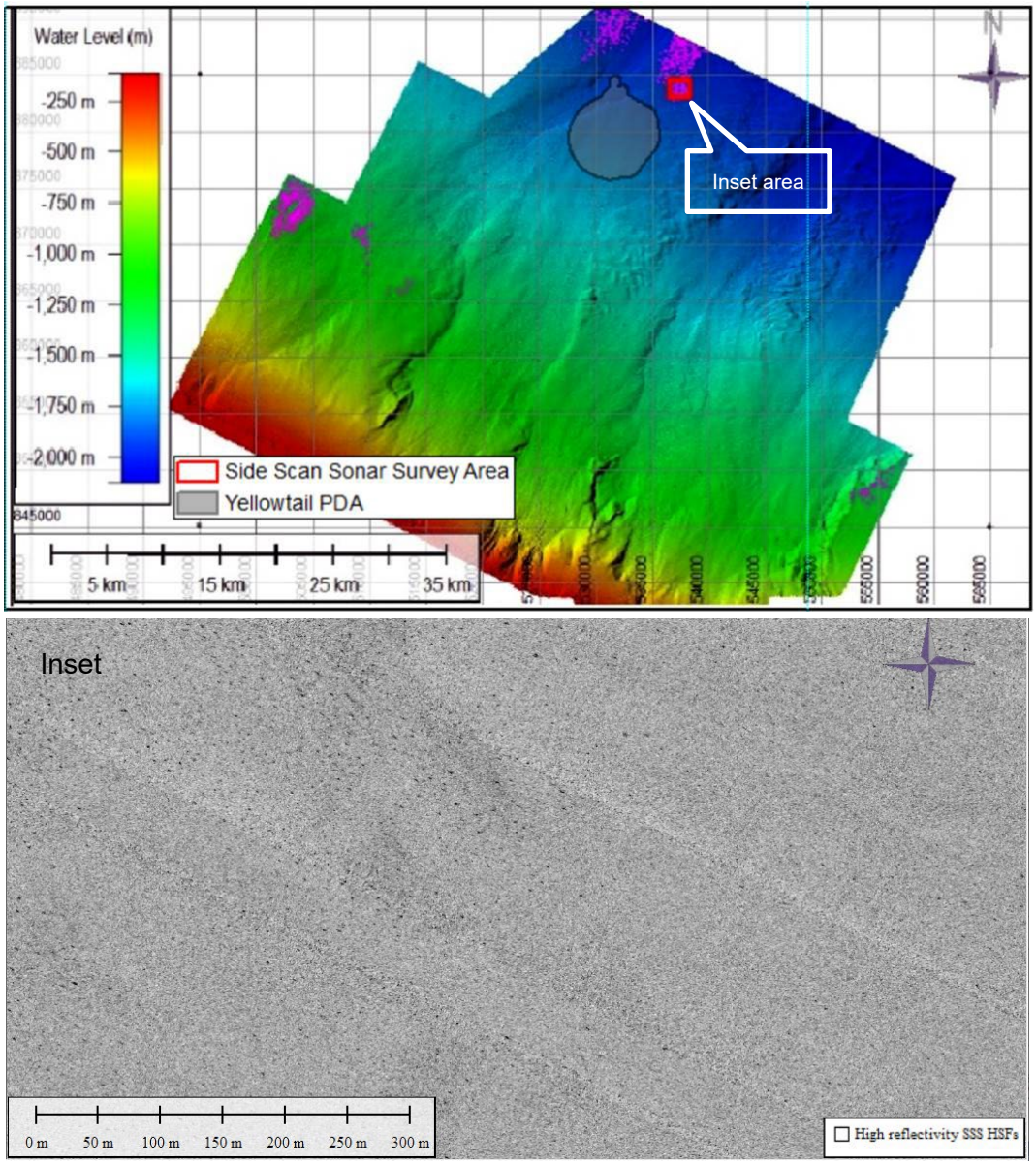


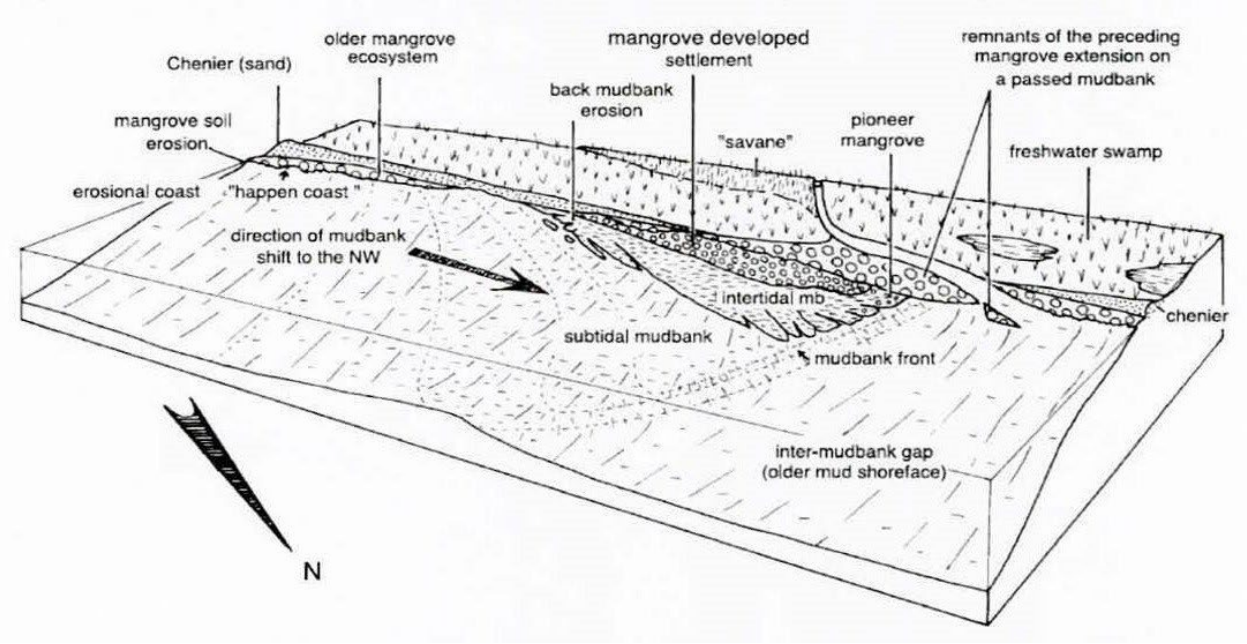
Figure 6.3-2: Identified Locations of Hard Seafloor Features in Yellowtail Geophysical Survey Area

[1] Turbidites are sea-bottom deposits formed by rivers flowing into the ocean that deposit sediments on the continental shelf and slope. When these deposits experience slope failure in response to excessive sedimentation load, they slide down to the ocean bottom to create a turbidite.

[2] Mass transport deposits are the sedimentary remains of submarine "landslides" and are distinctive due to their large size, distinctive morphology, and chaotic internal composition.

6.3.2.3. Marine Sedimentology

Fine clay and mud sediment are transported north from the mouth of the Amazon River and deposited approximately 21 to 60 kilometers (approximately 13 to 37 miles) offshore, to an average thickness of approximately 20 meters (approximately 65 feet) along Guyana's continental shelf (CGX 2009). Moving further out to sea (i.e., toward the edge of the continental shelf), sand gradually becomes the dominant sediment layer. The bathymetric profile of the continental shelf forms a generally smooth, gradual slope from nearshore to shelf edge, but a series of low mud ridges or mudbanks are located approximately 21 to 60 kilometers (13 to 37 miles) offshore (Figure 6.3-3).



Source: Royal Haskoning, Delft Hydraulics 2004

Figure 6.3-3: Typical Distribution of Mudbanks on Guyana's Coast

Although the Essequibo River and several other smaller rivers (e.g., the Demerara, Corentyne, and Berbice rivers) discharge large quantities of fine sediment, which are subsequently transported seaward and westward across the continental shelf, analysis of the humic content, nutrient composition, and ratio of surface area to mass of Guyanese marine sediments indicates that they are nearly identical to Amazonian sediments and unlike continental Guyanese sediments (Eisma and van der Marel 1971). This evidence strongly indicates that from a sedimentary perspective, the Guyanese continental shelf functions as a marine extension of the Amazonian delta system. At greater depths, calcarenite (coral fragment) substrates become more prevalent (Sætersdal et al.1999). The Stabroek Block occupies the transition area between the Amazonian-influenced zone and the older, deeper calcarenite zones.

In the PDA, the seabed sediments are comprised primarily of silty clay. Most stations sampled during the 2020 Yellowtail Project Geophysical Study comprised less than 30 percent sand, with high proportions of silt and clay fractions. The seabed sediments recorded within the Yellowtail PDA are similar in characteristic to those observed in the Liza 2 Field Development Environmental Baseline Surveys (EBS), with the mean value for the clay fractions exceeding 50 percent (Guardian Geomatics, 2020).

Sediment samples were collected from the Stabroek Block offshore Guyana as part of EBSs conducted in 2014 (Maxon and TDI-Brooks 2014), 2016 (Fugro 2016), 2017 (ESL 2018), 2018 (Maxon et al. 2019; Fugro 2019), 2019 (Appendix I; Maxon and TDI-Brooks 2019), and 2020 (Appendix I). The full 2014, 2016, and 2017 EBS reports were provided as Appendices G, H, and I of the Liza Phase 2 Development Project EIA. The 2018 Payara EBS report (Fugro 2019) was provided as Appendix I of the Paraya EIA. The 2018 Liza Phase 2 Development EBS (Benthic USA LLC. 2019) and the 2018 Canje EBS (Maxon et al. 2019) reports were provided as an appendix to the Canje 3-well Exploration Campaign Environmental Assessment and Management Plan. The 2019 Stabroek Block EBS report (Maxon and TDI-Brooks 2019) was provided as an appendix to the Stabroek 25-well Exploration Campaign Environmental Assessment and Management Plan. The 2019 and 2020 Hammerhead EBS reports are appended to this EIA (Appendix I, Recent Environmental Baseline Survey Reports).

As the EBS events were all conducted in the eastern part of the Stabroek Block or in the nearby Canje Block, the data from all EBS are relevant to describe sediment quality in the general vicinity of the PDA; the data from all these EBS events are therefore discussed herein.

Sediment samples have been collected from the Stabroek Block as follows:

- 10 sampling stations during the 2014 survey (Maxon and TDI-Brooks 2014);
- 25 sampling stations during the 2016 survey (Fugro Emu 2016);
- 10 sampling stations during the 2017 survey (ESL 2018);
- 8 sampling stations during the 2018 Liza Phase 2 survey (Maxon et al. 2019)
- 8 sampling stations during the 2018 Payara survey (Fugro 2019);
- 20 sampling stations during the 2019 Stabroek Block survey (Maxon and TDI-Brooks 2019)
- 8 sampling stations during the 2019 Hammerhead survey (see Appendix I); and
- 8 sampling stations during the 2020 Hammerhead survey (see Appendix I).

In addition, sediment samples were collected from 9 sampling stations in the Canje Block in 2018 (Maxon et al. 2019).

These locations are collectively referred to as the Study Area in this section. The stations included locations within the PDA as well as locations outside the PDA, within the southeastern portion of the Stabroek Block, along the continental shelf, and in the nearby Canje Block. A discussion of the results from all surveys is provided below. Summaries of the results for reported metals and hydrocarbon concentrations in the sampled sediments are presented in Table 6.3-2 and Table 6.3-3, respectively. Figure 6.3-4 shows the sediment sampling locations for the EBS events described above.

Table 6.3-2 includes the U.S. National Oceanic and Atmospheric Administration (NOAA) Effects Range Low (ERL) and Effects Range Median (ERM) values. These values are measures of toxicity in marine sediment and are used to evaluate whether a concentration of a contaminant in sediment might have toxicological effects. The ERL value indicates the concentration below which toxic effects are scarcely observed or predicted; the ERM value indicates the concentration above which effects are generally or always observed (Long et al. 1995). They are not regulatory criteria but define a benchmark as a concentration that, when exceeded, has the potential to cause harm or cause significant risk to organisms in the environment.[1]

Table 6.3-2: Summary of Metal Concentrations Reported for Sediment Samples (µg/g dry weight)

Parameter	Mean	Minimum	Maximum	Mean Background [a]	Effects Range Low [b]	Effects Range Median [c]
2014 EBS (n=10)						
Aluminum	11,495	8,100	15,000	77,440	—	—
Arsenic	6.1	4.5	11.4	2	8.2	70
Barium	98.9	57.4	159	668	—	—
Cadmium	0.125	0.102	0.165	0.102	1.2	9.6
Chromium	14.9	8.6	21.1	35	81	370
Copper	13.1	9.9	16.5	14.3	34	270
Iron	19,130	13,500	25,300	30,890	—	—
Lead	11.6	8.3	15.6	17	46.7	218
Mercury	0.042	0.026	0.062	0.056	0.15	0.71
Nickel	21.4	14.1	32.3	18.6	20.9	51.6
Vanadium	23.5	18.1	28.3	53	—	—
Zinc	45.5	26.9	63.7	52	150	410
2016 EBS (n=25)						
Aluminum	43,432	13,900	66,600	77,440	—	—
Arsenic	11.6	6.1	97.1	2	8.2	70
Barium	175	44	272	668	—	—
Cadmium	0.120	0.073	0.255	0.102	1.2	9.6
Chromium	36.1	14.5	53.4	35	81	370
Copper	20.2	6.9	30.5	14.3	34	270
Iron	30,364	12,100	98,100	30,890	—	—
Mercury	0.029	0.016	0.042	0.056	0.15	0.71
Selenium	0.22	0.05	0.75	0.083	—	—
Lead	15.5	9.9	27.5	17	46.7	218
Nickel	27.0	10.8	51.5	18.6	20.9	51.6
Zinc	69.7	32.5	101.0	52	150	410
2017 EBS (n=10)						
Aluminum (total)	6,510	2,900	13,000	77,440	—	—

[1] NOAA screening values are commonly used for comparison when in-country values are not available.

Parameter	Mean	Minimum	Maximum	Mean Background [a]	Effects Range Low [b]	Effects Range Median [c]
Arsenic (total)	15	3.6	50	2	8.2	70
Barium (total)	7.5	3.5	16	668	—	—
Cadmium (total)	BDL	BDL	BDL	0.102	1.2	9.6
Chromium (total)	15	7.7	24	35	81	370
Copper (total)	3.1	BDL	6.7	14.3	34	270
Iron (total)	20,720	8,900	35,000	30,890	—	—
Mercury (total)	BDL	BDL	BDL	0.056	0.15	0.71
Selenium (total)	BDL	BDL	BDL	0.083	—	—
Lead (total)	7.8	3.8	15	17	46.7	218
Nickel (total)	8.6	3.8	15	18.6	20.9	51.6
Zinc (total)	29	11	55	52	150	410
2018 Liza Phase 2 EBS (n=8)						
Aluminum	11,550	10,400	12,700	77,440	—	—
Arsenic	9.46	7.76	11.3	2	8.2	70
Barium	206	133	396	668	—	—
Cadmium	0.13	0.11	0.143	0.102	1.2	9.6
Chromium	26.0	22.3	27.8	35	81	370
Copper	21.2	19.3	23.1	14.3	34	270
Iron	20,363	17,900	23,100	30,890	—	—
Mercury	0.030	0.027	0.034	0.056	0.15	0.71
Selenium	26.8	22.4	32.5	0.083	—	—
Lead	14.8	13.5	16.5	17	46.7	218
Nickel	26.8	22.4	32.5	18.6	20.9	51.6
Zinc	69.3	62.4	77.6	52	150	410
2018 Payara EBS (n=8)						
Aluminum (total)	36,400	29,800	45,100	77,440	—	—
Arsenic (total)	37.8	6.62	250	2	8.2	70
Barium (total)	165	132	240	668	—	—
Cadmium (total)	BDL	BDL	BDL	0.102	1.2	9.6
Chromium (total)	30.3	24.5	38.9	35	81	370
Copper (total)	15.1	12.5	17.4	14.3	34	270
Iron (total)	33,700	17,700	122,000	30,890	—	—
Mercury (total)	0.0236	0.0206	0.027	0.056	0.15	0.71
Selenium (total)	0.63	0.50	1.53	0.083	—	—
Lead (total)	12.3	10.4	14.7	17	46.7	218
Nickel (total)	20	16.8	26.1	18.6	20.9	51.6
Zinc (total)	60.5	42.6	112	52	150	410
2018 Canje EBS (n=9)						
Aluminum	15,289	6,800	19,800	77,440	—	—
Arsenic	10.6	8.22	16.2	2	8.2	70

Parameter	Mean	Minimum	Maximum	Mean Background [a]	Effects Range Low [b]	Effects Range Median [c]
Barium	331	127	1,660	668	—	—
Cadmium	0.14	0.085	0.171	0.102	1.2	9.6
Chromium	27.7	16.7	32.9	35	81	370
Copper	27.25	9.61	34.9	14.3	34	270
Iron	23,256	15,900	29,800	30,890	—	—
Lead	15.05	7.64	19.4	0.056	0.71	0.15
Mercury	0.04	0.022	0.045	17	218	46.7
Nickel	29.56	12	39	18.6	20.9	51.6
Selenium	0.41	0.3	0.5	0.083	—	—
Zinc	76.4	47.2	90.9	52	150	410
2019 Stabroek Block EBS (n=20)						
Aluminum	9,895	4,400	14,100	77,440	—	—
Arsenic	10.25	5.96	33.5	2	8.2	70
Barium	982.1	10.1	17,600	668	—	—
Cadmium	0.140	0.084	0.437	0.102	1.2	9.6
Chromium	17.89	8.63	28.4	35	81	370
Copper	14.17	2.87	22.4	14.3	34	270
Iron	21,905	10,400	42,800	30,890	—	—
Lead	12.39	7.68	29.6	17	46.7	218
Mercury	0.03	0.012	0.051	0.056	0.15	0.71
Nickel	19.21	9.78	28.7	18.6	20.9	51.6
Selenium	0.35	0.2	0.7	0.083	—	—
Zinc	59.88	23.3	243	52	150	410
2019 Hammerhead EBS (n=8)						
Aluminum	52,100	39,000	60,000	77,440	—	—
Arsenic	8.9	5.8	11	2	8.2	70
Barium	199	140	240	668	—	—
Cadmium	0.14	0.11	0.17	0.102	1.2	9.6
Chromium	50	37	57	35	81	370
Copper	17	11	20	14.3	34	270
Iron	32,000	23,000	37,000	30,890	—	—
Mercury	0.038	0.025	0.043	0.056	0.15	0.71
Lead	19	14	39	17	46.7	218
Nickel	33	20	22	18.6	20.9	51.6
Selenium	-	<1	<1	0.083	—	—
Zinc	14	61	97	52	150	410
2020 Hammerhead EBS (n=8)						
Aluminum (%)	7.24	3.85	8.46	—	—	—
Barium	2644	250	16,200	668	—	—
Beryllium	1.50	0.24	2.03	—	—	—

Parameter	Mean	Minimum	Maximum	Mean Background [a]	Effects Range Low [b]	Effects Range Median [c]
Cadmium	0.16	0.15	0.18	0.102	1.2	9.6
Chromium	41.1	18.4	52.1	35	81	370
Cobalt	9.52	5.8	11.6	—	—	—
Copper	16.9	10.6	22	14.3	34	270
Iron	33,566	19,200	39,00	30,890	—	—
Lead	19.0	9.6	29.5	17	46.7	218
Manganese	608	313	906	—	—	—
Mercury	0.04	0.0286	0.0622	0.056	0.15	0.71
Molybdenum	1.15	0.5	1.64	—	—	—
Nickel	29.4	15.5	35.8	18.6	20.9	51.6
Strontium	489.4	384	659	—	—	—
Thallium	0.7	0.4	0.8	—	—	—
Tin	2.4	1.4	2.9	—	—	—
Vanadium	86.5	51.6	100	53	—	—
Zinc	80.6	43.2	114	52	150	410
Selenium	BDL	BDL	BDL	0.083	—	—
Silver	BDL	BDL	BDL	—	—	—

µg/g = microgram per gram; BDL = below detection limit; "—" = no Effects Range Low / Effects Range Median value available
Note: One-half of the detection limit was used for non-detect results in all statistical calculations.
[a] Mean concentration in upper continental crust (Wedepohl 1995)
[b] NOAA Effects Range Low value (Macdonald et al. 1996)
[c] NOAA Effects Range Median value (Macdonald et al. 1996)

Table 6.3-3: Summary of Hydrocarbon Concentrations Reported for Sediment Samples

Parameter	Mean	Minimum	Maximum	Background [a]
2014 EBS (n=10)				
Total SHC (µg/g)	10.64	8	14	NA
Total Unresolved SHC (µg/g)	6.97	3	12	NA
Total Resolved SHC (µg/g)	3.68	2	8.9	NA
Carbon Preference Index (CPI)	1.97	1.47	3.27	NA
Pristane (µg/g)	0.007	0.004	0.012	NA
Phytane (µg/g)	0.005	0.003	0.010	NA
Pristane/Phytane Ratio	1.34	0.67	1.8	NA
$nC_{16}/(nC_{15}+nC_{17})$	0.40	0.24	0.51	NA
Total Polycyclic Aromatic Hydrocarbons (PAHs) (ng/g)	38.61	24.58	53.36	NA
Petrogenic/Pyrogenic Ratio	3.36	2.14	4.65	NA
2016 EBS (n=25)				
Total Hydrocarbons (THC) (µg/g)	2.8	1.5	4.8	0.2-5
Unresolved Complex Mixture (UCM) (µg/g)	1.8	0.9	2.8	NA
n-alkanes nC_{12-20} (µg/g)	0.06	0.02	0.13	NA

Parameter		Mean	Minimum	Maximum	Background [a]
	nC_{21-36} (µg/g)	0.21	0.1	0.38	NA
	nC_{12-36} (µg/g)	0.27	0.12	0.5	NA
CPI	nC_{12-20}	1.29	1.1	2.41	NA
	nC_{21-36}	2.62	2.09	2.99	NA
	nC_{12-36}	2.22	1.83	2.7	NA
Pristane (µg/g)		0.002	0.001	0.013	NA
Phytane (µg/g)		0.003	0.001	0.012	NA
Pristane/Phytane Ratio		1.28	0.13	2.27	NA
Total PAHs (Sum of 2-6 Rings) (ng/g)		48	16	239	NA
Sum of 2-3 Rings (NPD) (ng/g)		16	6	82	NA
Sum of 4-6 Rings (ng/g)		32	10	157	NA
NPD/4-6 Ring		0.54	0.35	0.82	NA
2017 EBS (n=10) (detected constituents only)					
n-Dotriacontane (µg/g)		0.213	0.17	0.26	NA
n-Hexatriacontane (µg/g)		0.194	0.14	0.28	NA
n-Octadecane (µg/g)		0.14	BDL	1.4	NA
n-Triacontane (µg/g)		0.22	0.17	0.31	NA
Total Extractable Hydrocarbons		7.1	4.9	10	NA
2018 Liza Phase 2 EBS (n=8)					
Total PAH (ng/g)		20.60	17.83	22.59	NA
Total TPH (µg/g)		1.5	<1.4	2,21	NA
Unresolved TPH (µg/g)		-	<1.4	<1.4	NA
Resolved TPH (µg/g)		1.5	<1.4	2.21	NA
2018 Payara EBS (n=8)					
THC (µg/g)		0.7	0.6	0.8	0.2-5
UCM (µg/g)		0.4	0.4	0.5	NA
n-alkanes	nC_{12-20} (µg/g)	0.7	0.6	0.8	NA
	nC_{21-36} (µg/g)	0.4	0.4	0.5	NA
	nC_{12-36} (µg/g)	0.08	0.06	0.1	NA
CPI	nC_{12-20}	1.13	1.04	1.2	NA
	nC_{21-36}	2.71	2.45	2.92	NA
	nC_{12-36}	2.22	2.02	2.4	NA
Pristane (µg/g)		0.0007	0.0006	0.0009	NA
Phytane (µg/g)		0.0003	0.0002	0.0004	NA
Pristane/Phytane Ratio		2.42	2.06	3.17	NA
Total PAHs (Sum of 2-6 Rings) (ng/g) [b]		4	2	7	NA
Sum of 2-3 Rings (NPD) (ng/g)		1	BDL	2	NA
Sum of 4-6 Rings (ng/g)		3	-	5	NA
NPD/4-6 Ring		0.33	BDL	0.40	NA
2018 Canje EBS (n=9)					
Total PAH_{16} (ng/g)		10.38	5.58	15.71	NA
Total PAH_{44} (ng/g)		44.29	31.02	73.19	NA

Parameter		Mean	Minimum	Maximum	Background [a]
Total TPH (µg/g)		2.0	<1.36	4.15	NA
Total unresolved TPH (µg/g)		1.86	<1.36	3.44	NA
Total resolved TPH (µg/g)		1.39	<1.27	1.4	NA
2019 Stabroek Block EBS (n=20)					
Total PAH_{16} (ng/g)		8.99	2.90	17.68	NA
Total PAH_{44} (ng/g)		53.11	11.06	120.8	NA
Total TPH (µg/g)		9.18	2.14	33.23	NA
Total unresolved TPH (µg/g)		4.52	0.63	19.11	NA
Total resolved TPH (µg/g)		4.65	0.71	14.12	NA
2019 Hammerhead EBS (n=8)					
THC (µg/g)		2.6	2.0	3.7	NA
UCM (µg/g)		1.3	1.0	1.9	NA
n-alkanes	nC12-20 (µg/g)	0.07	0.03	0.08	NA
	nC21-36 (µg/g)	0.18	0.11	0.25	NA
	nC12-36 (µg/g)	0.25	0.15	0.32	NA
CPI	nC12-20	1.19	0.97	1.47	NA
	nC21-36	2.39	2.04	2.63	NA
	nC12-36	1.95	1.81	2.13	NA
Pristane (µg/g)		0.0018	0.0014	0.0025	NA
Phytane (µg/g)		0.0014	0.0012	0.0021	NA
Pristane/Phytane Ratio		1.25	0.92	1.58	NA
Total PAHs (Sum of 2-6 Rings) (ng/g) b		47	34	64	NA
2020 Hammerhead EBS (n=9) (calculated values include result for duplicate at station 2)					
Total TPH (µg/g)		267	3	1,233	NA
Total PAHs (ng/g)		121.44	37.2	319	NA

µg/g = microgram per gram; BDL = below detection limit; CPI = carbon preference index (the ratio of odd-number carbon chain n-alkanes to even-numbered carbon chain n-alkanes); NA = not applicable; ng/g = nanograms per gram; NPD = naphthalene, phenanthrene, anthracene, and dibenzothiophene (2 ring and 3-ring PAHs) SHC = saturated and aliphatic hydrocarbons

Notes:

Petrogenic/Pyrogenic = Ratio of the sum of combustion-related PAHs (fluoranthene, pyrene, chrysene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene) divided by the sum of petrogenic PAHs (naphthalene, acenaphthene, acenaphthalene, fluorene, phenanthrene, dibenzothiophenes, chrysenes, and fluoranthenes/pyrenes).

2-6 Ring PAH = Total 2- to 6-ring polycyclic aromatic hydrocarbons

nC_{12-20} = alkanes ranging from carbon numbers 12 to 20

nC_{21-36} = alkanes ranging from carbon numbers 21 to 36

nC_{12-36} = alkanes ranging from carbon numbers 12 to 36

[a] Typical THC levels (i.e., “background”) in sediments remote from anthropogenic activities (North Sea Task Force 1993)

[b] NOAA suggested Effects Range Low and Effects Range Median values for total PAHs of 4.022 µg/g and 44.792 µg/g, respectively (Long et al. 1995)

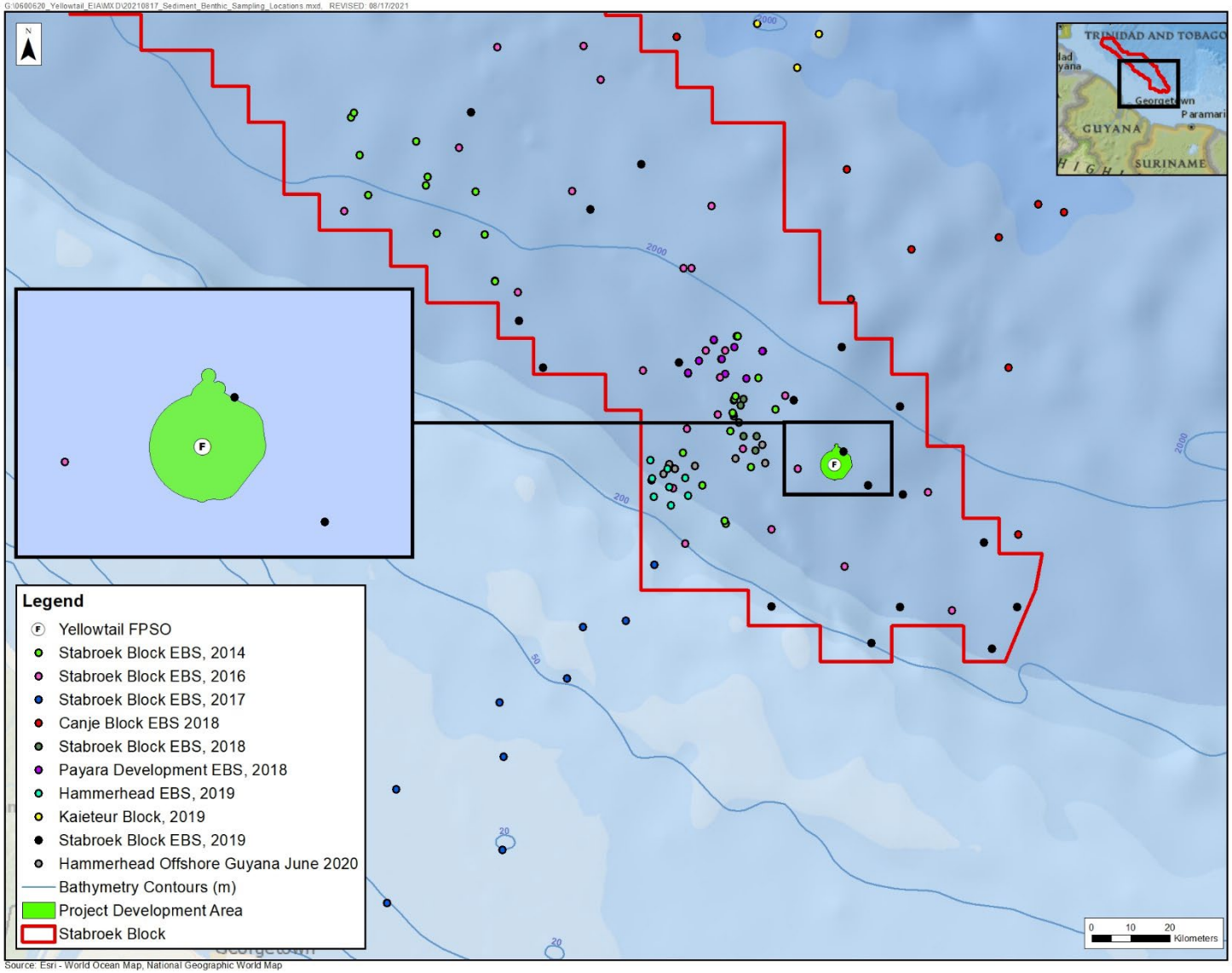


Figure 6.3-4: Sediment Sampling Locations for EBS Events Conducted to Date

2014 Survey

During the 2014 survey (TDI-Brooks 2014), sediment samples were analyzed for the following parameters:

- Total organic carbon (TOC)
- Metals
- Hydrocarbons

Total Organic Carbon

Concentrations of TOC were less than 1 percent at all survey stations. Higher concentrations of TOC were found in the southwest portion of the survey area, which is closer to shore.

Metals

Twelve metals were analyzed to assess general patterns of distribution across the Study Area. Of the 12 metals analyzed, 10 metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, vanadium, and zinc) were used as indicators of anthropogenic sources; the remaining 2 metals (aluminum and iron) were used to provide geological source information. All of the ten anthropogenic-indicator metals had concentrations similar to those reported for the upper continental crust (Wedepohl 1995) with the exception of arsenic, for which reported concentrations were slightly elevated (average of 6.1 micrograms per gram [µg/g] compared to an upper continental crust mean background concentration of 2 µg/g). However, all average concentrations were at or below the NOAA ERL values.

Hydrocarbons

Hydrocarbons are divided into two classes of compounds: aliphatic compounds and aromatic compounds. The hydrocarbon analysis consisted of the analysis of saturated and aliphatic hydrocarbons (SHCs)—including selected isoprenoids—and polycyclic aromatic hydrocarbons (PAHs).

Aliphatic compounds can be “saturated” (alkanes with carbon atoms joined by single bonds), or “unsaturated” (alkenes with carbons joined by double bonds). The study measured concentrations of total SHCs that encompass light and heavy fractions of petroleum (i.e., alkanes $nC_{9\text{-}40}$) and selected isoprenoids (branched chain unsaturated hydrocarbons), including pristane and phytane. Concentrations of total SHCs ranged from 8 µg/g to 14 µg/g. The unresolved portion of the SHC analysis (i.e., SHCs that cannot be identified through the use of standard analytical methods) ranged from 3 µg/g to 12 µg/g, with an average of 7 µg/g, which makes up approximately 66 percent of the reported average total SHCs concentration.

Several SHC-based parameters and ratios were used to distinguish between biogenic and petroleum-derived sources. These parameters and ratios are listed below, along with a general discussion of their relevance in determining the source of the hydrocarbons:

- Carbon Preference Index (CPI): The total odd-chain hydrocarbons divided by the total even-chain hydrocarbons. A value of 2 to 4 indicates input from plants. As petroleum is added, the value decreases, approaching 1.
- Pristane/Phytane Ratio: The source of phytane is mainly petroleum, whereas pristane is derived from both biological matter and petroleum. In environmental samples with no petroleum contribution, this ratio is greater than 1 and it decreases as petroleum is added.
- Hexadecane (nC_{16}) / (pentadecane [nC_{15}] + heptadecane [nC_{17}]) ratio: At "background" levels, hydrocarbons nC_{15} and nC_{17} can be used as indicators of plankton hydrocarbon inputs. As plankton productivity increases, this ratio decreases. If the ratio were to increase over time or within the data set, the rationale would be that it is related to anthropogenic sources. Hexadecane (nC_{16}) is rarely found in biolipids (Thompson and Eglinton 1978); paraffins of nC_{15}, nC_{17}, or nC_{19} have been found to be predominant in benthic algae (Clark and Blumer 1967; Youngblood et al. 1971).

The results of the sediment samples exhibited a predominance of odd-chain hydrocarbons as compared to even-chain hydrocarbons, with an average CPI value of approximately 2; this indicates a primarily biogenic source of hydrocarbons. This result is reasonable given the volume of land runoff from the Essequibo and Demerara rivers.

The average pristane/phytane ratio of 1.34 reflects a predominance of pristane over phytane in the sediments, also indicating a predominantly biogenic source of hydrocarbons.

The low ratio (less than 1) of nC_{16} over the sum of nC_{15} + nC_{17} for all samples also indicates relatively higher concentrations of plankton-related hydrocarbons, as compared to hydrocarbons from anthropogenic sources.

PAHs are composed of aromatic rings. PAHs analyzed included 20 parent (i.e., unalkylated) compounds and 23 alkylated homologues, consisting of 2- to 6-ring PAH compounds. Concentrations of total PAHs (all 43 analytes combined) ranged from 0.02458 µg/g to 0.05336 µg/g.

The sample distribution of individual PAHs provided information for a range of hydrocarbon sources. The petrogenic/pyrogenic distribution ratio listed below is useful to distinguish between petroleum-derived hydrocarbons and those derived from combustion of fossil fuels. The ratio increases as inputs from petroleum increase.

- Petrogenic/Pyrogenic Ratio—The ratio of the sum of petrogenic PAHs divided by the sum of pyrogenic (i.e., combustion-related) PAHs, where:
  - Petrogenic PAHs include naphthalene, acenaphthene, acenaphthalene, fluorene, phenanthrenes, and dibenzothiophenes, as well as the daughter compounds of the chrysenes and fluoranthenes/pyrenes; and

- Pyrogenic PAHs include the parent compounds of fluoranthene, pyrene, and chrysene, as well as benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.

In general, sample distributions of PAHs were dominated by the low molecular weight PAHs—naphthalenes and anthracene-phenanthrenes. The petrogenic/pyrogenic ratios of greater than 1 indicate hydrocarbons are from biogenic or natural material (potentially including petroleum-derived) rather than combustion-related compounds. High concentrations of perylene relative to other PAHs were also observed. Perylene is a biogenic compound linked to plant pigments from terrestrial runoff and is not indicative of either petrogenic or pyrogenic sources (Fugro 2016). Both total PAHs and total SHCs exhibited strong positive correlations with TOC, further supporting biogenic origins of the trace hydrocarbons.

Overall, the 2014 survey results indicate that biogenic or natural materials are the primary source of the low-level hydrocarbon concentrations measured during the survey. Biogenic hydrocarbon sources most likely consist of terrestrial plant and humic material transported to the survey area via river inputs.

2016 Survey

During the 2016 survey (Fugro 2016), sediment samples were analyzed for the following parameters:

- TOC
- Metals
- Hydrocarbons

Total Organic Carbon

Similar to the 2014 results, concentrations of TOC ranged from below the reporting limit to 1.1 percent. TOC concentrations were found to be higher at sampling locations with a greater proportion of fine sediments, indicating a negative correlation between grain size and organic content (logical given that smaller grain sizes have a greater surface area and thus more ability to adsorb organic matter).

Metals

Twelve metals were measured to determine general patterns of distribution across the survey area. Of the 12 metals analyzed, 10 metals (i.e., arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, vanadium, and zinc) were used as indicators of anthropogenic sources and 2 metals (i.e., aluminum and iron) were used to provide geological source information. The maximum concentrations of the individual metals measured during the 2016 survey were consistently higher than those from the 2014 survey; this is possibly a result of the different acids used by the 2014 and 2016 laboratories for extraction, or of greater variability in the data set due to the significantly larger sample area covered by the 2016 survey as compared to that of the 2014 survey. Average concentrations of anthropogenic-indicator metals arsenic and nickel exceeded their respective NOAA ERL values. While this may reflect the composition of

source material, there may be some contribution from terrestrial runoff contaminated from mining or other industries, as carried to the Guyana Basin via riverine inputs from Brazil and the Guiana Shield.

Hydrocarbons

The hydrocarbon analyses included measurements of total hydrocarbons (THCs) and PAHs.

THCs concentrations ranged from 1.5 µg/g to 4.8 µg/g. THCs showed positive correlations with metals concentrations, with the exception of copper and arsenic, as well as with TOC concentrations. The unresolved complex mixture (UCM; i.e., fraction of THCs that cannot be resolved/identified) concentrations ranged from 0.9 µg/g to 2.8 µg/g, and the average was 1.8 µg/g, which makes up 64 percent of the average THCs concentration. Concentrations of alkanes (nC_{12-36}) ranged from 0.12 µg/g to 0.50 µg/g. Reported concentrations of short-chain alkanes (nC_{12-20}) were consistently lower than those of long-chain alkanes (nC_{21-36}).

Several THC-based parameters and ratios were used to distinguish between biogenic and petroleum-derived sources. CPI values for the total range of alkanes (nC_{12-36}) ranged from 1.83 µg/g to 2.27 µg/g. These results display a predominance of odd-chain hydrocarbons over even-chain hydrocarbons, with an average CPI value greater than 2, indicating primarily biogenic sources of hydrocarbons. The average pristane/phytane ratio was 1.28, meaning a predominance of pristane over phytane exists in the samples, indicating the primary source of the hydrocarbons is likely biological.

Concentrations of total PAHs ranged from 0.016 µg/g to 0.239 µg/g. The ratio of the sum of naphthalene, phenanthrene, anthracene, and dibenzothiophene (NPD; petrogenic indicators) divided by the sum of 4 to 6 ring PAHs (pyrogenic indicators) is useful to determine the relative contributions of pyrogenic and petrogenic hydrocarbons. The ratio increases as inputs from petroleum increase. In general, samples showed a predominance of 4- to 6-ring PAHs (i.e., NPD/ 4- to 6-ring ratios of less than 1), indicating predominantly pyrogenic sources of hydrocarbons, as opposed to petrogenic sources. However, high concentrations of perylene (a biogenic compound linked to plant pigments from terrestrial runoff and not indicative of either petrogenic or pyrogenic sources) relative to other PAHs were also observed.

Overall, the 2016 survey results indicate the low levels of hydrocarbons measured in the Study Area could have derived from biogenic or natural materials as well as combustion-related compounds. Biogenic hydrocarbon sources most likely consist of terrestrial plant and humic material transported to the survey area via river inputs, while combustion-related emissions could arise from multiple natural or anthropogenic sources.

2017 Survey

During the 2017 survey (ESL 2018), sediment samples were analyzed for the following parameters:

- TOC
- Moisture content
- Oxidation-reduction (redox) potential
- Metals (total and bioavailable)
- Hydrocarbons

Total Organic Carbon

Consistent in general with the 2014 and 2016 surveys, concentrations of TOC were less than 1 percent in all ten samples. TOC concentrations tended to be higher in samples with higher clay content.

Moisture Content

Sediment moisture content is an important fundamental physical property that may be highly variable. Its value is dependent upon particle size and type, organic matter content, as well as physico-chemistry of the sediment. Temporal and special changes may occur in sediment porosity that also affect water content (Bennett et al. 1990). Sediment moisture content ranged from 22.1 percent to 38.6 percent, with an average value of 27.4 percent. There was limited variability among the samples; the highest value was measured at a station located 20 meters (66 feet) from the shoreline, and the lowest was measured at a station 67 meters (220 feet) from the shoreline, suggesting no correlation between depth and sediment moisture content.

Redox Potential

The redox state of sediment is the result of the combined effect of biological and chemical processes of a reversible and/or irreversible nature (Bågander 1978). Redox reactions control organic-matter oxidation and element cycling in aquatic ecosystems (Schlesinger and Bernhardt 2013). Redox conditions in surface sediments depend on the degree of organic enrichment (Zobell 1946). Organic enrichment of sediments usually leads to reduced conditions that equate to “poor” sediment quality (i.e., low dissolved oxygen and elevated ammonia or sulfide concentrations), wherein natural benthic communities undergo substantial changes (ECASA 2004). Negative redox potential values are therefore associated with anoxic conditions, in which the degradation of organic matter is performed by anaerobic bacteria (ECASA 2004). The values detected in all ten samples were positive, indicating oxic conditions within the sediment at the time of sampling.

Metals

Twelve metals were measured to determine general patterns of distribution across the survey area. Of the 12 metals analyzed, 10 metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc) were used as indicators of anthropogenic sources and 2 metals (aluminum and iron) were used to provide geological source information. Samples

were analyzed both for total concentrations of metals as well as bioavailable concentrations of metals. The average concentrations and ranges of concentrations for all metals were comparable to those observed during the 2014 and 2016 surveys.

The average concentration of one anthropogenic indicator metal (arsenic) exceeded the NOAA ERL value. When the 2016 survey results for total arsenic and iron were taken into consideration, it was observed that almost all the values showed a strong positive correlation. A comparison of the 2017 arsenic/iron correlation to the 2016 data further revealed that seven of the ten detected values of 2017 were consistent with the background levels recorded in 2016. Thus, the observed variation in total arsenic concentrations at most of the 2017 sampling stations likely reflect natural background concentrations associated with variation in sediment geochemistry. For the remaining three stations, the higher arsenic-to-iron ratios are likely indicative of anthropogenic inputs.

The bioavailable concentrations of metals were below detection levels for most of the metals in most samples. The exceptions were two detections of bioavailable aluminum (14 µg/g and 20 µg/g) and one detection of bioavailable arsenic (1.3 µg/g).

Hydrocarbons

All ten samples were analyzed for the full suite of saturated hydrocarbons, which constituted a total of 39 individual analytes. Five of the 39 analytes were detected at one or more stations, while the remaining 34 analytes (87 percent) were not detected above their respective detection levels at all ten stations. Only two of the five detected hydrocarbon analytes were detected at all ten stations. Where detected, saturated hydrocarbons ranged from 0.14 to 10 milligrams per kilogram (mg/kg), with n-dotriacontane concentrations consistent across the ten stations, while n-hexatriacontane concentrations varied with distance from the shoreline.

2018 Liza Phase 2 Survey

During the 2018 Liza Phase 2 survey (Maxon et al. 2019), sediment samples were analyzed for the following parameters:

- Grain size
- Redox potential
- TOC
- Metals
- Hydrocarbons

Grain Size

Grain size was reported for four major classes based on the percent composition of each class: gravel, sand, silt, and clay. Fine-grained material dominated the 2018 Study Area, with all samples containing greater than 74 percent silts and clays. Sand contributed a minor but relatively consistent component, ranging from 13.69 to 25.27 percent across stations. These results indicate fairly homogeneous sediments, comprising a narrow range of class sizes based on the Wentworth scale, typical of slope and basin depth depositional areas.

Redox Potential

Nearly all redox measurements taken at 2-, 5-, and 10-centimeter (0.8-, 2-, and 3.9-inch) depths below the sediment surface were moderately high and positive, which is typical for oxygenated, fine-grained slope sediment.

TOC

Similar to grain size, TOC results varied little across stations and were within the range of values reported from the 2014 survey. These results are typical of lower-slope offshore sediments in tropical waters.

Metals

Twelve metals were analyzed in sediment samples. Ten metals commonly associated with anthropogenic sources were analyzed along with aluminum and iron, which were used to provide geological source information.

Offshore sediments collected from the Liza Phase 2 Study Area were reported to contain metal concentrations generally lower than those reported for offshore areas associated with undeveloped coastal environments, except for barium at two stations, noting that the reported concentrations were well below the threshold range of approximately 2,000 to 4,000 µg/g that is considered to be potentially harmful to benthic biota.

Hydrocarbons

Two classes of organic chemicals consisting of PAHs and saturated total petroleum hydrocarbons (TPH) were analyzed as indicators of age and source of petroleum-related hydrocarbons in sediments. Extremely low concentrations of hydrocarbons were measured in all sediment samples.

Both PAH and TPH results were lower than those measured in 2014. Total PAH_{44} (sum of all 44 analytes) ranged from 17.83 to 22.59 nanograms per gram (ng/g) dry weight. Concentrations of total TPH (sum of unresolved plus resolved hydrocarbons) also were extremely low, ranging from less than 1.4 to 2.21 µg/g, without any quantifiable unresolved TPH. There was no significant correlation between total PAH_{44} (or total PAH_{16}) and total TPH, possibly indicating different sources for these two hydrocarbon classes.

Hydrocarbon concentrations were lower than those reported for typical coastal sediments adjacent to relatively unpopulated or non-industrialized regions that receive minor hydrocarbon inputs.

2018 Payara Survey

During the 2018 Payara survey (Fugro 2019), sediment samples were analyzed for the following parameters:

- TOC
- Metals
- Hydrocarbons

Total Organic Carbon

TOC concentrations were generally consistent with those of prior surveys. Concentrations of TOC were less than 1 percent in all eight samples, with values ranging from 0.27 percent to 0.36 percent. The mean TOC value is comparable to the mean from the 2016 survey (0.32 percent; Fugro 2016). The TOC concentrations tended to be higher in samples with higher clay content.

Metals

As described previously, 12 metals were measured to determine general patterns of distribution across the survey area. The sediment levels of arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, vanadium, and zinc were used as indicators of anthropogenic sources, and levels of aluminum and iron were used to provide geological source information. In general, all of the anthropogenic indicator metals were reported at average concentrations below or similar to those reported for the upper continental crust (Wedepohl 1995), with the exception of arsenic and selenium. Selenium was detected in only one sample, and the concentration was above the mean concentration in the upper continental crust. With the exception of arsenic, all average concentrations were at or below their respective NOAA ERL values. While the level of arsenic may reflect the composition of source material, there may be some contribution from terrestrial runoff contaminated from mining or other industries, as carried to the Guyana Basin via riverine inputs from Brazil and the Guiana Shield.

The average concentrations of aluminum and iron were consistent with those reported for the upper continental crust.

Hydrocarbons

The hydrocarbon analyses for the 2018 study include the measurement of concentrations of THCs and PAHs. The concentrations of THCs ranged from 0.6 µg/g to 0.8 µg/g, with an average concentration of 0.7 µg/g. The concentrations of THCs across all sampled stations were lower than the average from the 2016 study. No spatial trends in THCs were apparent with any variation between stations likely to be a result of natural small-scale heterogeneity in sediment characteristics and associated THC concentrations. The concentration of UCM of THCs that cannot be resolved/identified ranged from 0.4 µg/g to 0.5 µg/g. The average was 0.4 µg/g, which makes up 57 percent of the average THC concentration.

Several THC-based parameters and ratios were used to distinguish between biogenic and petroleum-derived sources. CPI values for the total range of alkanes (nC12-36) ranged from

2.02 µg/g to 2.4 µg/g. These results display a predominance of odd-chain hydrocarbons over even-chain hydrocarbons, with an average CPI value greater than 2, indicating primarily biogenic sources of hydrocarbons. The average pristane/phytane ratio of 2.42 reflects a predominance of pristane over phytane in the sediments, also indicating a predominantly biogenic source of hydrocarbons.

Concentrations of total PAHs ranged from 0.002 µg/g to 0.007 µg/g. The ratio of the sum of NPD (petrogenic indicators) divided by the sum of 4- to 6-ring PAHs (pyrogenic indicators) is useful to determine the relative contributions of pyrogenic and petrogenic hydrocarbons. The ratio increases as inputs from petroleum increase. In general, samples showed a predominance of 4- to 6-ring PAHs (i.e., NPD/4- to 6-ring ratios of less than 1), indicating predominantly pyrogenic sources of hydrocarbons, as opposed to petrogenic sources.

Overall, as in the case of 2016 survey, the 2018 Payara survey results indicate that the low levels of hydrocarbons measured could have derived from biogenic or natural materials as well as combustion-related compounds. Biogenic hydrocarbon sources most likely consist of terrestrial plant and humic material transported to the survey area via river inputs, while combustion-related emissions could arise from multiple natural or anthropogenic sources.

2018 Canje Survey

During a survey of the Canje block undertaken in 2018 (Maxon et al. 2019), sediment samples were analyzed for the following parameters:

- Grain size
- TOC
- Oxidation-reduction (redox) potential
- Metals
- Hydrocarbons

Grain size

Sediment grain size was reported for four major classes based on the Wentworth scale: gravel, sand, silt, and clay. The majority of sediment samples were categorized as poorly to moderately sorted, fine-grained material, with clays as the dominant fraction (greater than 60 percent) at all but one station. All nine stations had sediment containing greater than 80 percent fines, with gravel-sized particles absent from all samples and sand contributing no more than 18 percent in any sample. Results indicate fairly uniform, silty-clay sediment comprised of a fairly narrow range of class sizes based on the Wentworth scale, typical of offshore depositional areas.

Total Organic Carbon

Concentrations of TOC were low (less than 1 percent) and fairly uniform across stations, consistent with lower slope and basin sediments in oligotrophic waters. There were no statistically significant ($p \geq 0.05$) relationships between particle size classes or TOC with water depth.

Redox Potential

Nearly all Redox potential (Eh) measurements taken at 2, 5 and 10 centimeters (0.8, 2, and 3.9 inches) below the sediment-water interface were moderately to highly positive (115.2 to 422.1 millivolts [mV]), which is within the normal range for oxygenated, fine-grained, low organic carbon sediment. Redox values are generally high and positive (greater than 300 to 500 mV) in sediments with porewater concentrations above the upper limit of hypoxia (i.e., greater than 2 milligrams per liter [mg/L] dissolved oxygen). In marine (or other eutrophic) sediments, microbial-mediated Redox processes can decrease Eh potential to a level as low as −300 mV, especially below the maximum depth of bioturbation, which is typically 4 to 6 centimeters in lower slope habitats.

Metals

Twelve metals were analyzed in samples of surface sediments to. Ten metals commonly associated with anthropogenic sources, consisting of arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc, were analyzed. Two additional metals, aluminum and iron, were analyzed to provide geological source information. Except for enriched barium at one station, reported metal concentrations were generally within natural background ranges reported for the Orinoco delta and the Sorubim block.

Concentrations of nickel, lead, and zinc were higher than the maximum background concentrations for Orinoco Delta and the Sorubim block surveyed in 2014; however, they were within natural ranges reported for lower slope and basin depth sediments in the Gulf of Mexico (Rowe and Kennicutt 2009) and within the natural range reported for the earth's upper continental crust (Wedepohl 1995). The only metal measured at over twice the regional background concentrations was barium at one station.

Hydrocarbons

Total PAH_{44} (sum of 44 PAH analytes) concentrations ranged from 31.0 to 73.2 ng/g dry weight. Concentrations of total TPH ranged from 1.2 to 14.0 µg/g (mean = 9.5 µg/g). There was no significant correlation between total PAH and total TPH concentrations, indicating non-petroleum related sources. Furthermore, reported hydrocarbon concentrations were within the range reported in the Sorubim survey area in 2014, prior to the start of any exploration activities (Maxon and TDI-Brooks 2014).

2019 Stabroek Block Survey

During the 2019 Stabroek Block survey (Maxon and TDI-Brooks 2019), sediment samples were analyzed for the following parameters:

- Grain size
- TOC
- Metals
- Hydrocarbons

Grain size

The samples were typical of the transitional zone between terrestrial muds and marine calcarenites, consisting of a patchy distribution of a relatively wide range of class sizes. Most of the stations were categorized as poorly sorted, fine-grained material comprised mainly of silts and clay, except at five stations where sand was dominant (greater than 43 percent) (Maxon and TDI-Brooks 2019). Coarse-grained foraminifera and shell fragments were also observed at several sampling stations.

TOC

Concentrations of TOC were low to moderate (0.29 to 1.31 percent) and fairly homogenous across all stations, which is typical of slope sediments in oligotrophic waters (Maxon and TDI-Brooks 2019). The maximum reported TOC concentration (2.65 percent) was observed at one station located in the productive waters of the continental shelf at a depth of 125 meters (Maxon and TDI-Brooks 2019).

Metals

Reported concentrations of metals were within previously reported background ranges and similar to reported concentrations for the Atlantic lower slope and basin depth sediments. Chromium, copper, iron, nickel, lead, and zinc were within the normal range of those reported for sediments originating from the Amazon River, with the exception of one station (S07) containing elevated barium at a concentration 100 times higher (17,600 µg/g) than the other 19 stations (less than 172 µg/g) (Maxon and TDI Brooks 2019). The highest concentration of lead and mercury were also recorded at station S07; however, the concentrations of these metals were within normal ranges and consistent with background concentrations previously recorded in the Stabroek Block. Concentrations of barium greater than 5,000 µg/g typically indicate an anthropogenic source (Maxon and TDI Brooks 2019).

Six of the 10 indicator metals had strong positive correlations with aluminum and/or iron, indicating that geological minerals are the likely source of the observed metals. Copper, mercury, and nickel had the strongest correlation with aluminum, indicative of natural aluminosilicate minerals as the metal-bearing phase. Relatively high concentrations of iron at one station in the southeastern Stabroek Block indicate different sources of marine sediment between shelf-depth and deeper sediments (Maxon and TDI Brooks 2019).

Hydrocarbons

Relatively low concentrations of PAH and TPH were measured in all 20 sediment samples. PAH and TPH concentrations were slightly higher for this survey than from the 2014 EBS campaign, but were generally lower than concentrations reported for coastal and shelf sediments elsewhere. A significant, positive correlation between total PAH and sediment size of clay was found, likely due to the high results for both parameters measured in sediments. There were no significant correlations apparent between PAH or TPH and sediment grain size of sand and silt, TOC, or water depth. There was also no significant correlation apparent between total PAH and

total TPH, indicating non-petroleum related sources of southern Stabroek Block sediment for these hydrocarbon classes (Maxon and TDI Brooks 2019).

2019 Hammerhead Survey

During the 2019 Hammerhead survey (Fugro 2019b), sediment samples were analyzed for the following parameters:

- Grain size
- TOC
- Metals
- Hydrocarbons

Grain Size

Although the sediment composition was broadly similar across the Hammerhead survey area, four stations were classified as ‘fine silt’, three stations were classified as ‘very fine silt’, and the remaining station classified as ‘medium silt’. The majority of the sediments were classed as very poorly sorted, with one station classified as poorly sorted. All stations had a sediment composition consisting of mainly sand and fines content.

Total Organic Carbon

TOC content ranged from 0.53 to 0.74 percent, with a mean of 0.64 percent. This compares to a mean TOC content recorded in the Payara survey area of 0.31 percent (Fugro 2019) and a mean TOC content of 0.31 percent in the Liza field (Fugro 2016). The mean TOC values observed for each depth in the Hammerhead survey area were comparable, suggesting no evidence of stratification.

Metals

Sediments from the Hammerhead survey area were analyzed for aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium and zinc. Mean metal concentrations were generally higher within the Hammerhead survey area as compared to those in the Payara survey area (Fugro 2019b), with the exception of arsenic, which had a single high concentration outlier recorded in the 2018 Payara EBS.

Metals concentrations were compared against their respective NOAA ERL and ERM values (Buchman 2008). With the exception of arsenic and nickel, metal concentrations were generally lower than their NOAA ERL levels. No metal concentrations exceeded NOAA ERM. In the case of arsenic and nickel, similar concentrations of these metals have been recorded elsewhere in the region.

Hydrocarbons

The THC concentrations recorded within the survey area ranged from 2.0 µg/g to 3.7 µg/g, with a mean of 2.6 µg/g. The UCM concentration ranged from 1.0 µg/g to 1.9 µg/g, with a mean of 1.3 µg/g - higher than that recorded in the Payara survey area (Fugro 2019). No spatial trends

were observed and any variation between stations is likely to be due to natural heterogeneity in sediment characteristics.

Total PAH concentrations in the Hammerhead survey area ranged from 0.034 to 0.064 µg/g, with a mean concentration of 0.047 µg/g. The mean total PAH concentration recorded at the Hammerhead development was higher than the mean recorded in the Payara survey area, but comparable to those recorded in the Liza field (Fugro 2016). For the 16 priority PAHs designated by the USEPA, the mean concentrations from the Hammerhead survey area were below the NOAA ERL and ERM threshold concentrations (Buchman 2008).

2020 Hammerhead Survey

During the 2020 Hammerhead survey (Appendix I, Recent Environmental Baseline Survey Reports), sediment samples were analyzed for the following parameters:

- Grain Size
- TOC
- Redox Potential
- Metals
- Hydrocarbons

Grain Size

Sediment grain size for all stations was mainly silty clay, based on Shepard's classification (Shepard, 1954). Most stations were characterized by sediment with less than 30 percent sand and high proportions of silt and clay fractions. The grain size had a mean value for the clay fractions exceeding 50 percent.

Total Organic Carbon

TOC concentrations for sediments were generally consistent with prior surveys. Concentrations of TOC were less than 1 percent in all eight samples, with values ranging from 0.17 to 0.6 percent. These low TOC concentrations are similar to the concentration range of 0.33 to 0.57 percent fall within the expected range for deepwater offshore sediments (Escobar-Briones and García-Villalobos, 2009).

Redox Potential

The Eh values reported for all eight samples were positive, ranging from 100 to 233 mV, indicating aerobic conditions. There was an indirect correlation between Eh values and sediment depth, with decreasing values occurring with increasing depth.

Metals

Twenty metals were analyzed to determine general patterns of distribution across the Hammerhead Development EBS Study Area. Of the 19 metals analyzed, eight metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc) were used as indicators of priority pollutants. Aluminum and iron were indicators of the sediment mineral type.

The respective USEPA ERL and ERM guideline values were provided for metals, where available. Total selenium and silver concentrations were below the analytical laboratory's reporting limit of 8 mg/kg and 0.16 mg/kg, respectively. When compared to benchmarks, arsenic and nickel concentrations exceeded the ERL values at 6 of 8 stations for the study. Neither arsenic nor nickel concentrations exceeded the ERM values. All other metals concentrations for the survey were below their respective ERL benchmarks, where applicable.

Sediment metal concentrations within the Hammerhead EBS survey area were generally comparable to the sediments from the 2018 Liza 2 Development EBS (Benthic USA LLC. 2019) with the exceptions of aluminum, barium, selenium, and vanadium. Selenium had much lower concentrations (less than half), while aluminum, barium, and vanadium had much higher concentrations than observed in the 2018 Liza 2 Development EBS (Benthic USA LLC. 2019).

In particular, aluminum concentration for this survey showed a seven-fold increase in the mean (7.24 percent) when compared to the 2018 Liza 2 Development EBS (1.15 percent) (Maxon et al. 2019). The variability observed for aluminum concentrations, ranging from 3.85 to 8.46 percent, for this EBS exceeds the concentration range of 1.04 to 1.27 percent observed during the 2018 Liza 2 Development EBS (Maxon et al. 2019). The observed aluminum concentration during the Hammerhead Development EBS is expected for deep-water clay sediments (Turekian and Wedepohl 1961; Salomons and Förstner 1984; Wedepohl 1995). The sources for the differences between this EBS and the 2018 Liza Phase 2 EBS sediment aluminum concentrations are uncertain, but could be influenced by analytical laboratories and associated methods between surveys, natural influx of aluminosilicate terrigenous sediments, and/or anthropogenic activities (Appendix I, Recent Environmental Baseline Survey Reports).

Hydrocarbons

Hydrocarbons in sediments analyzed for the 2020 study included TPH and PAHs. TPH concentrations ranged from 3 µg/g to 1,233 µg/g. The sediment TPH levels were generally elevated when compared with the sediments from the Liza Phase 2 Development EBS (Maxon et al. 2019), which had extremely low levels, ranging from less than 1.4 µg/g to 2.21 µg/g. Total PAH concentrations in sediment ranged from 37.2 µg/g to 319 ng/g. The total PAH values within the 2020 Hammerhead EBS Study Area were elevated relative to the sediments from the 2018 Liza Phase 2 Development EBS (Maxon et al. 2019), which had relatively low total PAH levels, ranging from 17.83 µg/g to 22.59 ng/g. All detectable concentrations of priority pollutant PAHs were below respective ERL values.

6.3.3. Impact Assessment—Marine Geology and Sediments

This section addresses potential impacts on marine geology and sediments resulting from planned Project activities. The potential impacts assessed include changes to seafloor morphology from accumulation of discharged drill cuttings on the seafloor and changes to sediment quality from the residual hydrocarbon contained on the discharged drill cuttings.

During installation of the FPSO and SURF components, there will be some localized disturbance of sediments in a limited area. The installation of suction piles or driven piles and

flowlines on the seafloor may result in localized disturbance of the upper seabed sediment, but without introducing any foreign material. Given the largely cohesive nature of the seafloor material (i.e., silty clay— greater than 70 percent; see Section 6.3.2.3, Marine Sedimentology), the seafloor is expected to be largely resilient to scour. In coarse sediment areas with a high proportion of fines, usually greater than 10 percent, the coarse particles are subjected to the cohesive forces of the fines (Fugro Atlantic 2011) and are less likely to be easily scoured.

In terms of the potential for stability of the substrate to be affected by FPSO and SURF installation activities, Table 6.3-4 summarizes relevant findings.

Table 6.3-4: Summary of Assessment of Potential for Seabed Stability Effects from FPSO/ SURF Installation Activities

Project Component	Assessment of Potential for Seabed Stability Effects
FPSO Anchor Clusters	The anchor piles will be installed into the substrate using suction pressure. There is no energy transmission to the soil material outside the anchor pile, as in the case of driven piles. Therefore, given the low permeability of the soft clays encountered in the Yellowtail PDA, there will be no effect on the shear strength, porosity, or compressibility of the substrate. The seafloor material in the PDA is classified as predominantly silty clay. Based on the soil behavior of such silty clays, the seafloor has a low susceptibility to erosion or scour. Therefore, there is no appreciable risk of increased erosion. In the region where the mooring chains interact with the seafloor—from the pile padeye at depth (approximately 16 to 17 meters [53 to 56 feet] below the mudline) to the seafloor surface roughly 25 to 30 meters (82 to 98 feet) away from the suction pile centerline in the direction toward the FPSO, the repeated movement of the chain induced from the movement of the FPSO may create a trench feature approximately 25 to 30 meters (82 to 98 feet) in front of the suction pile, about 6 meters (20 feet) in width and up to the padeye depth. This trench is expected to be created within a few years of start of FPSO operations, and to remain present throughout the life of the FPSO. The impact of the trench is accounted for in the anchor pile design.
Drill Centers	The piles at the drill centers will be installed into the substrate using suction pressure, similar to those installed at the FPSO anchor clusters. As with the FPSO anchor clusters, there is no energy transmission to the soil material outside the anchor pile, as in the case of driven piles. Therefore, given the low permeability of the silty clays encountered in the Yellowtail PDA, there will be no appreciable effect on the shear strength, porosity, or compressibility of the substrate. The seafloor material in the PDA is classified as silty clay. Based on the soil behavior of such silty clays, the seafloor has a low susceptibility to erosion or scour. Therefore, there is no appreciable risk of increased erosion. Due to the absence of a mooring chain, the drill center piles are primarily vertically loaded. Trenching will therefore not occur at the drill centers. Additionally, selected subsea infrastructure may be founded on mud mats with skirts. The mud mats are designed to have a larger contact surface with the seafloor than the subsea infrastructure itself, thereby reducing the contact pressure exertion onto the seafloor. This results in reduced stress/pressure applied onto the seafloor, and thus there will be almost no change in porosity and compressibility. As part of detailed design, the stability of the mud mats will be checked against vertical, horizontal, and rotational forces (and combinations thereof).

Project Component	Assessment of Potential for Seabed Stability Effects
Flowlines/ Umbilicals	The flowlines and umbilicals will be laid in place onto the seafloor. Due to the very soft nature of the seafloor, there will be some amount of self-weight penetration of the flowlines and umbilicals, although the self-weight penetration is expected to be <0.3 meter (<1 foot). Detailed calculations will be performed to determine the self-weight penetration, as well as the pipe-soil interaction curves (spring curves) developed specific to the flowline/umbilical configurations. There will be some amount of consolidation as a consequence of the self-weight penetration, but this is expected to have minimal changes on shear strengths, porosities, and compressibilities. The seafloor material in the Yellowtail PDA is classified as silty clay. Based on the soil behavior of such silty clays, the seafloor will have a low susceptibility to erosion or scour. Therefore, there is no appreciable risk of increased erosion.
Riser Touchdown Points	The riser will contact the seafloor and cyclically interact with the seafloor as a consequence of the FPSO's movement due to metocean forces. The motion will remold the seabed sediment within the touchdown zone and will decrease the shear strength (to a fraction of the undisturbed shear strength). The remolded strength will be determined based on sediment sensitivity from laboratory testing (to be performed from samples collected from the PDA). The remolding is expected to also locally impact the porosity and compressibility. This is typical of riser touchdown points, and the effects (if any) will be analyzed during detailed design. The remolding will not impact the silty clays' susceptibility to erosion or scour. Therefore, there is no appreciable risk of increased erosion.

No impacts on marine geology and sediments are expected as a result of activities associated with production operations. Depending on the approach taken during decommissioning, there may be some minor sediment disturbance associated with retrieval of subsea infrastructure that is not abandoned in place on the seafloor.

Based on the above assessment concluding no reasonable potential for marine sediment stability impacts as a result of FPSO and SURF installation, the remainder of this section focuses on potential impacts on marine geology and sediments as a result of drilling development wells. Additional discussion regarding potential impacts on marine benthos from accumulation of discharged drill cuttings on the seafloor and changes to sediment quality from the residual hydrocarbon contained on the discharged drill cuttings is provided in Section 7.9.3, Impact Assessment—Marine Benthos.

6.3.3.1. Relevant Project Activities and Potential Impacts

The process of drilling development wells will produce drill cuttings that will be discharged either directly to the seafloor (in open-hole sections drilled riserless and with seawater) or from the drill ship (after treatment, including solids control and processing through a centrifugal cuttings dryer system) into the ocean (in sections drilled with a riser). The planned development drilling program and its cuttings management approach is consistent with good international oilfield practices (World Bank 2015; IMO 2003; IMO 2018). For each well, approximately 4,300 to 4,600 barrels (bbl) (688 to 736 cubic meters [m^3]) of cuttings for the riserless sections will be discharged directly to the seafloor per good international oilfield practice, as these sections will be drilled using water-based drilling fluids (WBDF) instead of non-aqueous drilling fluid (NADF) (World Bank 2015). For sections drilled with a riser, approximately 2,500 bbl of cuttings (per well) will be generated and treated to reduce associated drilling fluids to acceptable discharge

thresholds before discharge from the drill ship into the ocean (refer to Chapter 2, Description of the Project, for a description of the drilling process). Planned discharges of drill cuttings and fluids will potentially impact the marine sediment layer locally as a result of accumulation of cuttings on the seafloor. Cuttings will accumulate on the seafloor around the well locations, with the distribution of cuttings determined by oceanographic conditions.

Table 6.3-5 summarizes the Project stages and activities that could result in potential impacts on marine geology and sediments.

Table 6.3-5: Summary of Relevant Project Activities and Key Potential Impacts—Marine Geology and Sediments

Stage	Project Activity	Key Potential Impacts
Development Well Drilling	Discharge of drill cuttings during drilling of wells, and resulting deposition of cuttings on the seafloor	• Changes to seafloor morphology from accumulated drill cuttings • Impacts on sediment quality from deposition of residual hydrocarbon on discharged cuttings

6.3.3.2. Characterization of Impacts—Changes to Seafloor Morphology

Magnitude of Impact—Changes to Seafloor Morphology

To aid in assessing the magnitude of predicted changes to seafloor morphology from discharge of drill cuttings, modeling of cuttings deposition was performed using the Generalized Environmental Modeling System for Surfacewaters (GEMSS) model. This 3D particle-based model uses Lagrangian[12] algorithms in conjunction with currents, specified mass load rates, release times and locations, particle-size distributions, settling velocities, and shear stress values to calculate the fate and transport of discharged drill cuttings. Model outputs provide estimates of the thickness of deposits on the seafloor, and the mass distribution of base hydrocarbon (adhered to the cuttings) across the seafloor.

For the purpose of assessing drill cuttings deposition on the seafloor, a total of eight drill cuttings deposition scenarios were modeled: two scenarios at Drill Center DC1-I (the shallowest of the Project drill centers) and two scenarios at Drill Center DC3-P (the deepest of the Project drill centers), with each of those four scenarios under two current conditions—the minimum and the maximum of the monthly averaged and depth-averaged current speeds (see Table 6.3-6). The scenarios reflected two different hypothetical progressions of drilling operations selected to assess various possible outcomes for sediment deposition and water quality impacts. The current speeds were derived from the SAT-OCEAN ocean circulation model. As described below, the modeled deposition scenarios reflect combinations of top-hole section drilling (containing WBDF) with cuttings discharged at the seafloor, and bottom-hole drilling (containing NADF cuttings) with cuttings discharged overboard from the drill ship following treatment, per

[12] A gridless model in which pollutant particles move according to the wind field, buoyancy, and turbulence effects. Term is often used to differentiate such models from Eulerian models, which use a gridded model domain.

good international oilfield practice (World Bank 2015)—each for multiple wells within a single drill center cluster.

Table 6.3-6 summarizes the results of the modeling for the above-referenced drill cuttings discharge scenarios.

Table 6.3-6: Summary of Modeling Results for Drill Cuttings Discharge Scenarios

Drill Center	Scenario [a]	Maximum Predicted Thickness (cm)	Total Area (m^2) with Predicted Thickness > 5 cm
DC1-I	1-Minimum Currents	560.8	8,381
	1-Maximum Currents	443.1	7,234
	2-Minimum Currents	247.1	1.632
	2-Maximum Currents	258.4	1,939
DC3-P	1-Minimum Currents	190.3	3,969
	1-Maximum Currents	200.2	3,436
	2-Minimum Currents	126.7	2,135
	2-Maximum Currents	169.8	1,814

cm = centimeter; m^2 = square meters

[a] Scenario 1 reflects seabed discharges from sequential jetting/drilling of two top-hole sections (sections 1 and 2) at each of four well locations at a drill center using WBDF, with discharges of cuttings at the seabed. Scenario 2 reflects seabed discharges from sequential jetting/drilling of two top hole sections (sections 1 and 2) at two well locations at a drill center using WBDF, with discharges of cuttings at the seabed, followed by drilling of bottom-hole sections (sections 3 and 4) of the second well with NADF, with overboard discharges of treated cuttings.

Modeling of cuttings discharge and deposition indicates the maximum depositional thickness of cuttings on the seafloor is predicted to be between 126.7 and 560.8 centimeters (49.9 and 220.8 inches), depending on currents, drill center location, and scenario. From a change in seafloor morphology standpoint, a depositional thickness of 560.8 centimeters (220.8 inches) represents approximately 0.3 percent of the total water column depth of approximately 1,723 meters (6,234 feet) at Drill Center DC1-I, and thus changes to the regional seafloor topography from cuttings deposition—even within the localized area around the drill center where deposition would occur—will be insignificant.

Modeling indicates that the cuttings for the initial open-hole sections will settle relatively close to the well, as they are discharged at the seafloor. In contrast, the cuttings for the lower well sections are subjected to greater dispersion, as they are distributed by the currents during their settling through the water column.

A literature-based deposition threshold rate of 5 centimeters (2 inches) per month (Ellis and Heim 1985; MarLIN 2019) was used to assess the extent of the area with the potential to impact benthic organisms via smothering (an indirect impact resulting from impacts on marine sediment morphology, further discussed in Section 7.9.3, Impact Assessment—Marine Benthos). This threshold represents the accumulation rate above which benthic organisms would be expected to be unable to overcome the rate of deposition and become smothered, thereby limiting their mobility and access to oxygen.

While the above results are expressed in terms of total depositional thickness at completion of the identified drilling scenarios, it is appropriate to compare these total thicknesses to the deposition threshold rate of 5 centimeters (2 inches) per month. This is based on the fact that the scenarios selected for modeling were designed to simulate drilling activities with the potential to result in the greatest combined deposition at a given location within a 30-day period. Additional detail regarding the drill cuttings deposition modeling is presented in Appendix C, Water Quality Modeling Report.

In terms of magnitude, the potential impact of drill cuttings deposition on sediment morphology was viewed in the context of the resource's overall functionality with respect to providing a habitat for benthic organisms. In this sense, the magnitude rating is expressed based on the fraction of the overall resource being impacted at any one time by the Project. If it is conservatively assumed that up to three drill ships could be active simultaneously on Yellowtail drill centers, and that these drill ships are all undertaking drilling that matches the simulated scenarios, the conservative approach is therefore to triple the affected area results from Table 6.3-6 to reflect the largest area predicted to be subjected to a cuttings deposition rate greater than 5 centimeters (2 inches) per month at any one time. This results in a predicted area of approximately 25,143 square meters (m^2) (approximately 270,637 square feet [ft^2]), which represents approximately 0.07 percent of the area of the Subsea PDA (which itself covers approximately 0.1 percent of the Stabroek Block). Further, the currents are expected to redistribute the cuttings away from their initial deposition sites over time, gradually reducing their thickness on the seafloor at these locations.

The assessment of the Project's magnitude of potential impacts on seafloor morphology is determined based on consideration of geographic extent, intensity, frequency, and duration. The intensity of potential impacts on changes to seafloor morphology is defined according to the definitions provided in Table 6.3-7. The potential direct impacts are to seabed morphology; however, as this can have an indirect impact on marine biota, as discussed above, the sensitivity of marine biota receptors have been taken into account in assigning the level of sensitivity. Impacts on marine biota from drilling-related discharges are discussed further in Section 7.8, Marine Fish and Section 7.9, Marine Benthos. Although the scientific community has broadly accepted the North Brazil Shelf Large Marine Ecosystem (LME) as the relevant regional ecological unit to assess and manage ecological functions (see Section 7.10.2, Existing Conditions—Ecological Balance and Ecosystems), it is deemed that the North Brazil Shelf LME is too large an area to use to assess the geographic extent element of the intensity rating. Therefore, and to ensure an element of conservatism in the analysis, smaller geographic areas have been used to determine intensity of potential impacts on marine geology and sediments. The following paragraphs discuss the characteristics of the potential impact on seafloor morphology and the resultant magnitude rating.

Table 6.3-7: Definitions for Intensity Ratings for Potential Impacts on Seafloor Morphology

Criterion	Definition
Intensity	Negligible: No changes to overall functionality with respect to providing a habitat for benthic organisms.
	Low: Changes to overall functionality with respect to providing a habitat for benthic organisms, but limited to a localized area (i.e., within the PDA).
	Medium: Changes to overall functionality with respect to providing a habitat for benthic organisms over a moderately sized area (i.e., up to 5 km beyond the PDA).
	High: Widespread changes to overall functionality with respect to providing a habitat for benthic organisms (i.e., more than 5 km beyond the PDA).

km = kilometer

As deposition above the 5 centimeters (2 inches) threshold will occur over a very localized area in the immediate vicinity of the drill centers (up to a maximum distance of approximately 50 to 70 meters (164 to 230 feet) from the drill center for four of the modeling scenarios, and up to a maximum distance of approximately 300 to 365 meters (984 to 1,198 feet) from the drill center for the other two modeling scenarios, all within the PDA), the intensity of impact associated with changes in seafloor morphology is considered **Low**. While there will be periods during the drilling stage when cuttings deposition will not occur, the impact will be present essentially throughout the drilling stage, yielding a **Continuous** frequency rating. Drilling for the Project is expected to occur over multiple years, so the duration is considered **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude of impact on sediment morphology from drill cutting deposition is considered **Small** (see Table 6.3-8).

Table 6.3-8: Magnitude Ratings for Potential Impacts on Changes to Sediment Morphology

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Development Well Drilling	Change of seafloor morphology (considering habitat functionality as an indirect impact)	Direct AOI (PDA)	Low	Continuous	Long-term	Small

Sensitivity of Resource—Changes to Seafloor Morphology

Table 6.3-9 provides the definitions used to assign ratings for the sensitivity of marine sediments to changes in morphology. As discussed above, sensitivity ratings consider sensitivity of marine biota to potential indirect impacts on these receptors.

Table 6.3-9: Definitions for Sensitivity Ratings for Potential Impacts on Seafloor Morphology

Criterion	Definition
Sensitivity	Low: Affected habitat does not support any unique or otherwise critically important species.
	Medium: Affected habitat supports unique or critically important species, but represents only a small portion of the habitat on which these species depend.
	High: Affected habitat supports unique or critically important species, and represents a substantial portion of the habitat on which these species depend.

As discussed in Section 6.3.2, Existing Conditions—Marine Geology and Sediments, Guyana's mudbanks are critically important as feeding zones for birds, nursery areas for fish, and habitat for a variety of invertebrates. This subset of marine sediments would thus warrant a higher sensitivity rating if they were to be experience potential impacts from the Project. However, they are located on the nearshore portion of the continental shelf, well outside the area that modeling indicates will be affected by drill cuttings deposition. Accordingly, the sensitivity rating is focused on marine sediments other than mudbanks.

Based on the definitions above, the sensitivity of the overall marine sediment resource (considering sensitivity of potentially indirectly impacted marine biota) to potential changes in morphology from drill cuttings deposition is considered **Low**, as the deepwater sediments on which drill cuttings will settle do not support high densities of unique marine species; this was corroborated by multiple EBS events, deepwater fish surveys, and remotely operated vehicle surveys that have been carried out in the Stabroek Block, as well as the geophysical survey conducted in the vicinity of the Yellowtail PDA (Guardian Geomatics 2020). These ecological communities are discussed further in Section 7.8, Marine Fish, and Section 7.9, Marine Benthos.

Impact Significance—Changes to Seafloor Morphology

Based on the magnitude of impact and receptor sensitivity ratings described above, the pre-mitigation significance of potential impacts on sediment morphology from discharge of drill cuttings is considered **Negligible**.

6.3.3.3. Characterization of Impacts—Sediment Quality

Magnitude of Impact—Sediment Quality

The embedded controls in the Project design that will reduce the potential impact of drilling discharges on sediment quality include: (1) use of WBDF to the extent reasonably practicable (for drilling of initial open-hole well sections), and (2) use of NADF in all other cases. WBDF contains no hydrocarbons; accordingly, no treatment of WBDF-based cuttings is required and

there will be no impacts on sediment quality as a result of drill cuttings deposition from sections of the wells drilled with WBDF. When NADF is used for bottom-hole sections, the discharge of treated cuttings will be controlled such that residual non-aqueous base fluid (NABF) content on discharged cuttings will average no more than 6.9 percent (wet weight). The NABF will be International Association of Oil and Gas Producers (IOGP) Group III low-toxicity, with low to negligible aromatic content, reducing the potential that changes in sediment quality as a result of discharge of the treated cuttings will lead to potential toxicological impacts on benthic fauna.

The assessment of the Project's magnitude of potential impacts on sediment quality is determined based on consideration of geographic extent, intensity, frequency, and duration. The intensity of potential impacts on sediment quality is defined according to the definitions provided in Table 6.3-10. The following paragraphs discuss the characteristics of the impact on sediment quality and the resultant magnitude rating, which is summarized in Table 6.3-11.

Table 6.3-10: Definitions for Intensity Ratings for Potential Impacts on Sediment Quality

Criterion	Definition
Intensity	Negligible: No changes in sediment quality that would result in adverse effects to receptors.
	Low: Changes in sediment quality that could result in adverse effects to receptors, but limited to a localized area (i.e., within the PDA).
	Medium: Changes in sediment quality that could result in adverse effects to receptors over a moderately sized area (i.e., up to 5 km beyond the PDA).
	High: Changes in sediment quality that could result in adverse effects to receptors over a widespread area (i.e., more than 5 km beyond the PDA).

km = kilometer

The maximum concentration of NABF retained on cuttings will be 6.9 percent. The NABF will be a Group III NABF as defined by the International Association of Oil and Gas Producers (OGP 2003). Group III NABF includes fluids that contain levels of total aromatics below 0.5 percent and PAH levels below 0.001 percent. The 6.9 percent NABF on cuttings discharge criterion is applied specifically for Group III NABF on the basis that this concentration of compounds qualifying as IOGP Group III designation are protective of the benthic environment.

This is further supported quantitatively by consideration of potential toxicity from PAHs in the NABF. Conservatively assuming no mixing of the settled cuttings with the existing sediment on the seafloor, and based on the maximum PAH concentration in Group III NABF (0.001 percent), the maximum possible concentration of PAHs in deposited cuttings would be 0.69 µg/g. This can be compared to the ERL sediment quality guidelines developed by NOAA, which is 4.022 µg/g for total PAHs. This further demonstrates that there would not be an anticipated toxic impact to receptors (marine biota) from the anticipated impacts to sediment quality as a result of drill cuttings discharges.

Based on these factors described above, and considering the embedded controls that will dictate the use of an IOGP Group III NABF and reduce the mass of residual NABF in discharged cuttings to no more than the above-referenced international standard, the intensity of impact associated with drill cuttings discharge impact on sediment quality is considered **Negligible**. While there will be periods during the drilling stage when cuttings deposition will not

occur, the impact will be present as long as the NABF-containing cuttings are in contact with the seabed, yielding a **Continuous** frequency rating. While the concentrations of NABF will reduce over time through biodegradation and redistribution by currents, drilling for the Project is expected to occur over multiple years, and the duration is conservatively considered **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude of impact on sediment morphology from drill cutting deposition is considered **Negligible** (see Table 6.3-11).

Table 6.3-11: Magnitude Ratings for Potential Impacts on Sediment Quality

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Development	Sediment quality	Direct AOI	Negligible	Continuous	Long term	Negligible

Sensitivity of Resource—Sediment Quality

Designation of the sensitivity of marine sediments with respect to sediment quality was conducted using the same definitions presented for potential sediment morphology impacts from drill cuttings deposition (Table 6.3-9). Accordingly, the sensitivity of marine sediments to sediment quality impacts from drill cuttings deposition is considered **Low**.

Impact Significance—Sediment Quality

Based on the magnitude of impact and resource sensitivity ratings, the pre-mitigation significance of potential impacts on marine sediment quality as a result of drill cuttings deposition is considered **Negligible**.

6.3.4. Management Measures—Marine Geology and Sediments

Based on the **Negligible** significance of potential marine geology and sediment quality impacts, no mitigation measures are proposed. It is noted, however, that the limited significance of potential marine geology and sediment impacts is supported by a suite of embedded controls related to discharge management (see summary in Chapter 13, Recommendations).
Table 6.3-12 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 6.3-12: List of Embedded Controls and Monitoring Measures

Embedded Controls
Use water-based drilling fluids to the extent reasonably practicable (upper sections of the wells). For well sections requiring NADF, use only low-toxicity International Oil and Gas Producers Group III NABF.
When NADF is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.
Implement chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances and consider the Offshore Chemical Notification Scheme as a resource for chemical selection in Project production operations. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes; • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.
Monitoring Measures
Monitor daily during drilling to ensure that end of well maximum weighted mass ratio averaged over all well sections drilled using NABF do not exceed 6.9 percent wet weight base fluid retained on cuttings.

Table 6.3-13 summarizes the assessment of potential pre-mitigation and residual Project impacts on marine geology and sediments. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, and the marine geology and sediment-specific methodology described in Sections 6.3.3.2 and 6.3.3.3.

Table 6.3-13: Summary of Potential Pre-Mitigation and Residual Impacts—Marine Geology and Sediments

Stage	Resource - Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Well Drilling	Sediment morphology—changes from drill cuttings deposition (considering habitat functionality as an indirect impact)	Small	Low	Negligible	None	Negligible
	Sediment quality—impacts from residual NABF on deposited drill cuttings (considering habitat use as an indirect impact)	Negligible	Low	Negligible	None	Negligible

6.4. MARINE WATER QUALITY

6.4.1. Administrative Framework—Marine Water Quality

Table 6.4-1 summarizes the legislation, policies, or treaty commitments that focus specifically on water quality.

Table 6.4-1: Legislation, Policies, or Treaty Commitments—Water Quality

Title	Objective	Relevance to the Project
Legislation		
Environmental Protection Water Quality Regulations, 2000	Enables the EPA to set effluent standards for discharges to inland or coastal waters or land of Guyana (none have been issued in final form to date), establishes authorization requirements for discharges to inland or coastal waters, and requires holders of such authorizations to establish effluent sampling points as required by the EPA.	Establishes a basis for regulating discharge of listed substances to inland or coastal waters, which could include substances used as part of the Project.
International Agreements Signed/Acceded by Guyana		
International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) (Guyana acceded in 1997)	Regulates various forms of marine pollution, including oil and fuel, noxious liquid, hazardous substances, sewage, garbage, air emissions, and ballast water.	Applies to the handling and disposition of regulated substances from Project drill ships, FPSO, and support vessels.
International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004	Controls the release of ballast water in national waters for all vessels.	Applies to the management of ballast water from Project drill ships, FPSO, and support vessels.

6.4.2. Existing Conditions—Marine Water Quality

6.4.2.1. Oceanographic Conditions

Guyana's marine environment is bounded, and heavily influenced, by the Orinoco and Amazon rivers in Venezuela and Brazil, respectively. During the rainy season, Guyana's coastal marine waters receive large volumes of freshwater discharges from these major rivers, as well as from Guyana's own Essequibo, Demerara, and Berbice rivers (FAO 2005).

Guyana's surficial marine waters are crossed by the Guiana Current, which is part of the northern limb of the North Atlantic Meridional Overturning Circulation (MOC). The North Atlantic MOC circulates water between the subtropics and polar region. The Guiana Current derives from the North Brazil Current (NBC) flowing north along the northeastern coast of South America from northern Brazil toward the southeastern Caribbean Sea. As it reaches French Guiana, part of the NBC separates from the coast to join the North Equatorial Counter Current (NECC), while the rest continues flowing northwest to form the Guiana Current. Figure 6.4-1 illustrates the proximity of the Guiana Current, NBC, and NECC to the Stabroek Block.

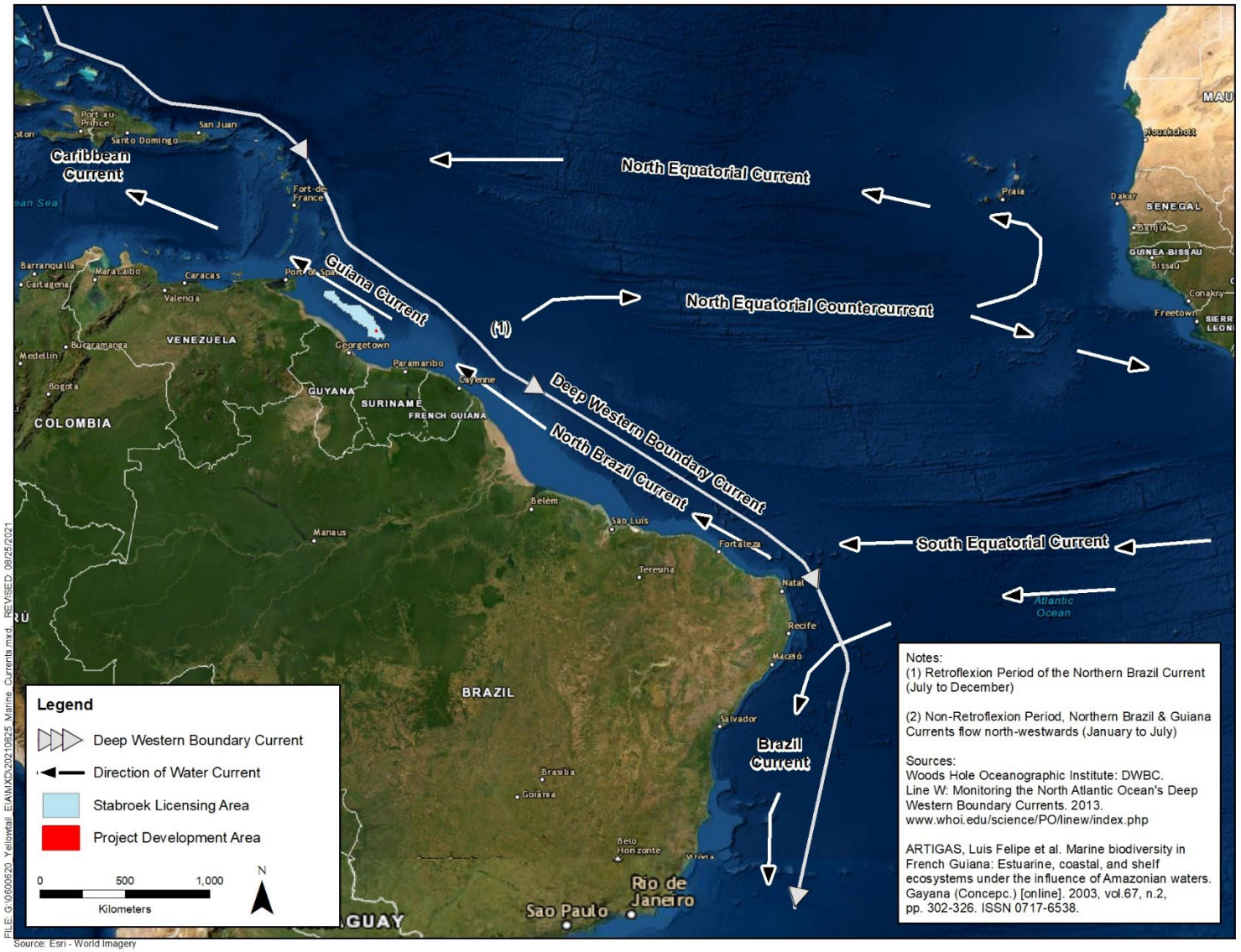


Figure 6.4-1: Marine Currents in the Vicinity of the Project Development Area

Several times a year, the NBC turns back on itself to create closed circulation and form regions of strong eddies (circular currents). These eddies can separate the NBC and NECC and travel northwest along the South American coast. The eddies may range from approximately 145 to 400 kilometers (approximately 90 to 250 miles) in diameter and current magnitude within the eddies can vary significantly depending on the depth.

During the spring, the Guiana Current can extend as far as 300 nautical miles (550 kilometers) offshore to cover Guyana's entire continental shelf. Its highest velocities tend to occur along the edge of the continental shelf (i.e., in Guyana just shoreward of the Stabroek Block). Fluctuations in the ITCZ and the trade winds lead to significant variation in the strength of the Guiana Current and the extent of its influence offshore, but maximum speeds generally occur from April to May, while minimum speeds commonly occur in September (Gyory et al. 2013).

The Guiana Current primarily influences the upper portion[13] of the water column, while the deeper portion of the water column in the Stabroek Block is strongly influenced by the North Atlantic Deep Western Boundary Current (DWBC), which is the southward limb of the North Atlantic MOC. The North Atlantic DWBC returns colder, denser water from polar regions to the subtropics at intermediate and deep levels.

In May 2014, EEPGL commissioned a Lowered Acoustic Doppler Current Profiler (LADCP) survey at four stations along a transect in the central portion of the Stabroek Block. The LADCPs were placed at depths ranging from approximately 970 to 1,100 meters (3,182 to 3,609 feet). To supplement the above data, in March 2016, an EEPGL contractor deployed and maintained a series of four deepwater current profile mooring buoys and one surface met station buoy (RPS 2016; 2017a, b, c; 2018b). Two of the mooring buoys were deployed in the Liza field along with a surface met station buoy, and the remaining two mooring buoys were deployed northwest of the Liza field. During the deployment in September 2017, the two Liza field mooring buoys were installed at the same locations, but the met station buoy was relocated. Figure 6.4-2 shows the locations of the LADCPs (shown as "Station 1" through "Station 4"), the two Liza field mooring buoys (shown as "LF" and "LG"), and the surface met station buoy (shown as "LC").

[13] There is limited information documenting the depths at which the Guiana Current and North Atlantic Deep Western Boundary Current (DWBC) exert an influence, but metocean data collected by EEPGL (Figure 6.4-3) suggests the Guiana Current exerts an influence in at least the top 200 meters (approximately 656 feet) and the North Atlantic DWBC exerts an influence at depths of more than 800 meters (approximately 2,625 feet). The strength of the Guiana Current will also likely dictate how deep its influence extends at a given time, as it weakens/strengthens depending on the winds and Amazon River flows.

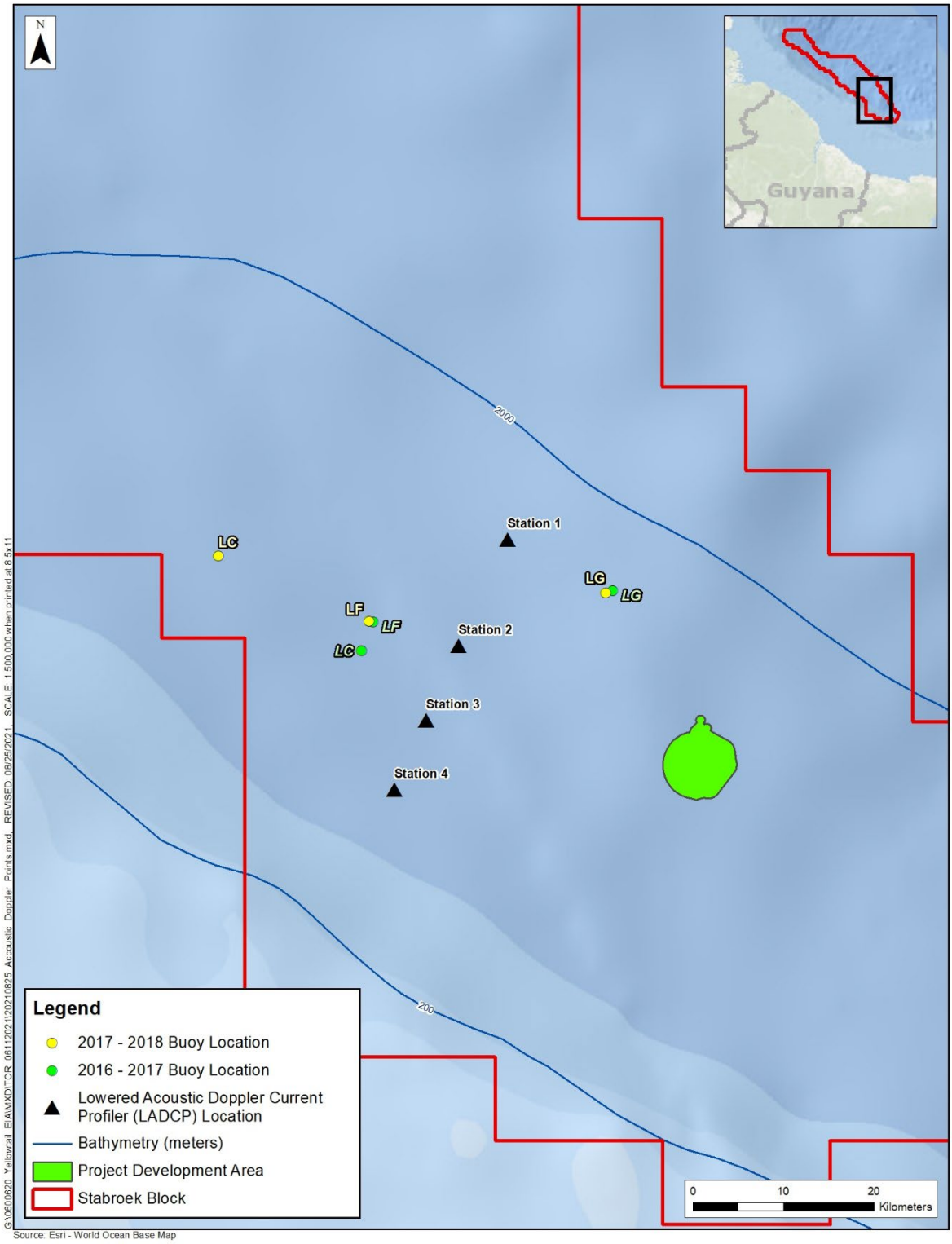
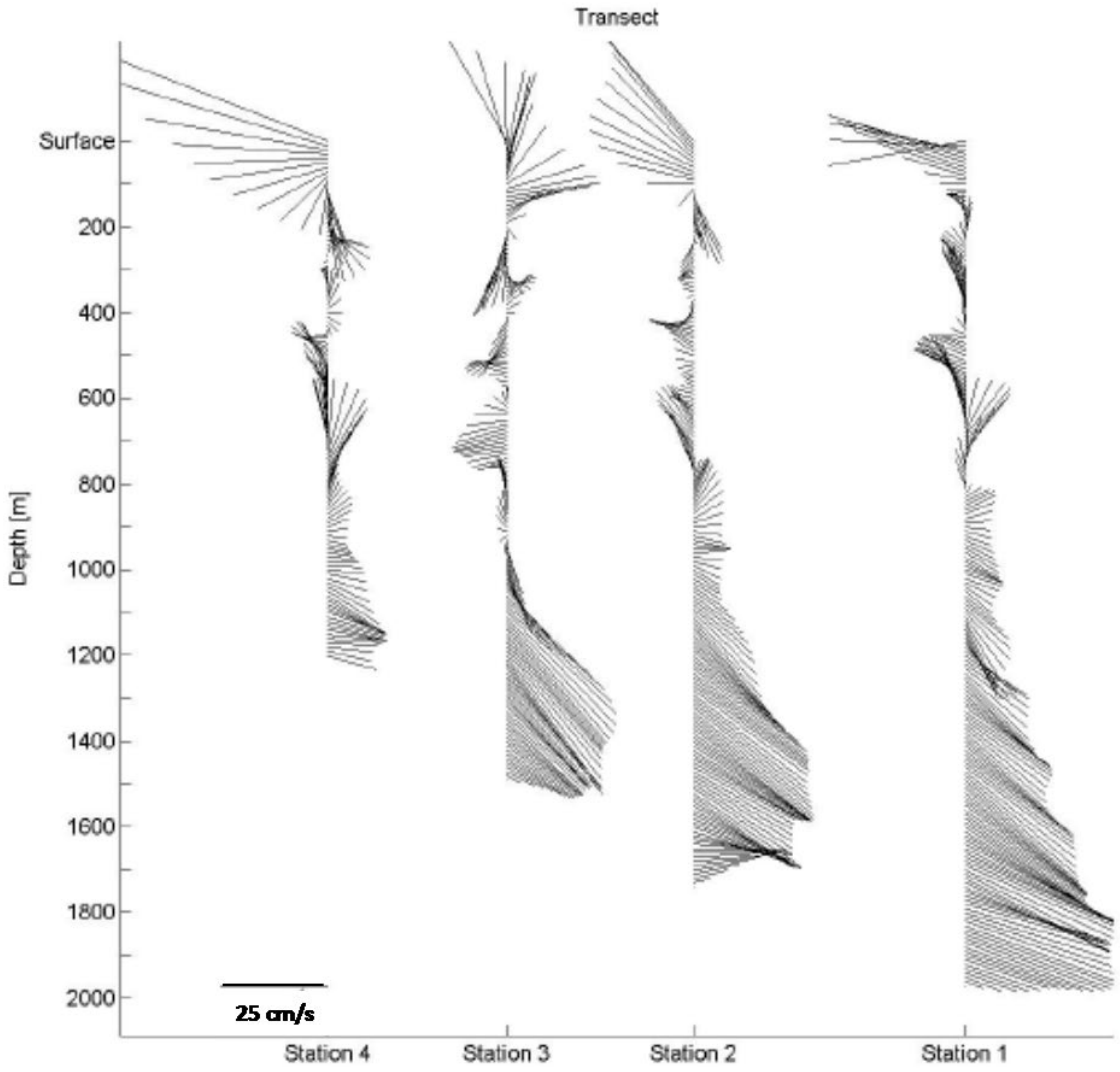


Figure 6.4-2: LADCP and Buoy Locations

The LADCP data indicate the presence of both the Guiana Current and the North Atlantic DWBC. Figure 6.4-3 shows vector stick plots from the four stations along the LADCP transect. The three deepest stations (Stations 1, 2, and 3) showed similar vertical current structure (i.e., a north-westward surface flow influenced by the Guiana Current and a south-eastward deep flow influenced by the North Atlantic DWBC). The shallowest station (Station 4) showed a similar layered structure, but the speed of the north-westward surface current was significantly greater at this station than at the others (TDI-Brooks 2014).

Processed final datasets from the mooring buoys were developed for buoy deployments spanning March 2016 through April 2018, including the fifth deployment that spanned from mid-September 2017 to early April 2018. In addition to confirming the overall circulation pattern off the coast of Guyana as measured in 2014, these moorings also helped identify regional current phenomena. For example, the data showed the existence of a northwest/north-northwest (NW-NNW) current that is characteristic of the NBC current at this location (see data from “LF” mooring buoy on Figure 6.4-4). The currents shown on the plot are directed toward the NW-NNW with a strong magnitude starting around 19 February 2017. The NBC is an aperiodic current, and Figure 6.4-4 shows the onset of the leading edge of this current reaching the LF mooring buoy location. The vector stick plot (Figure 6.4-3) shows a point in time when the NBC ring was present at the LADCPs. The most recent dataset (RPS 2018b) showed four significant pulses of surface currents during early to mid-October, early to mid-January, late February, and early April. All four of these events were toward the west-northwest, characteristic of the general direction of the Guiana Current. The near-bottom current magnitudes averaged from 18 to 20 centimeters per second (cm/s) at the LF buoy location and from 24 to 28 cm/s at the LG buoy location, representative of the south-eastward deep flow influenced by the North Atlantic DWBC.

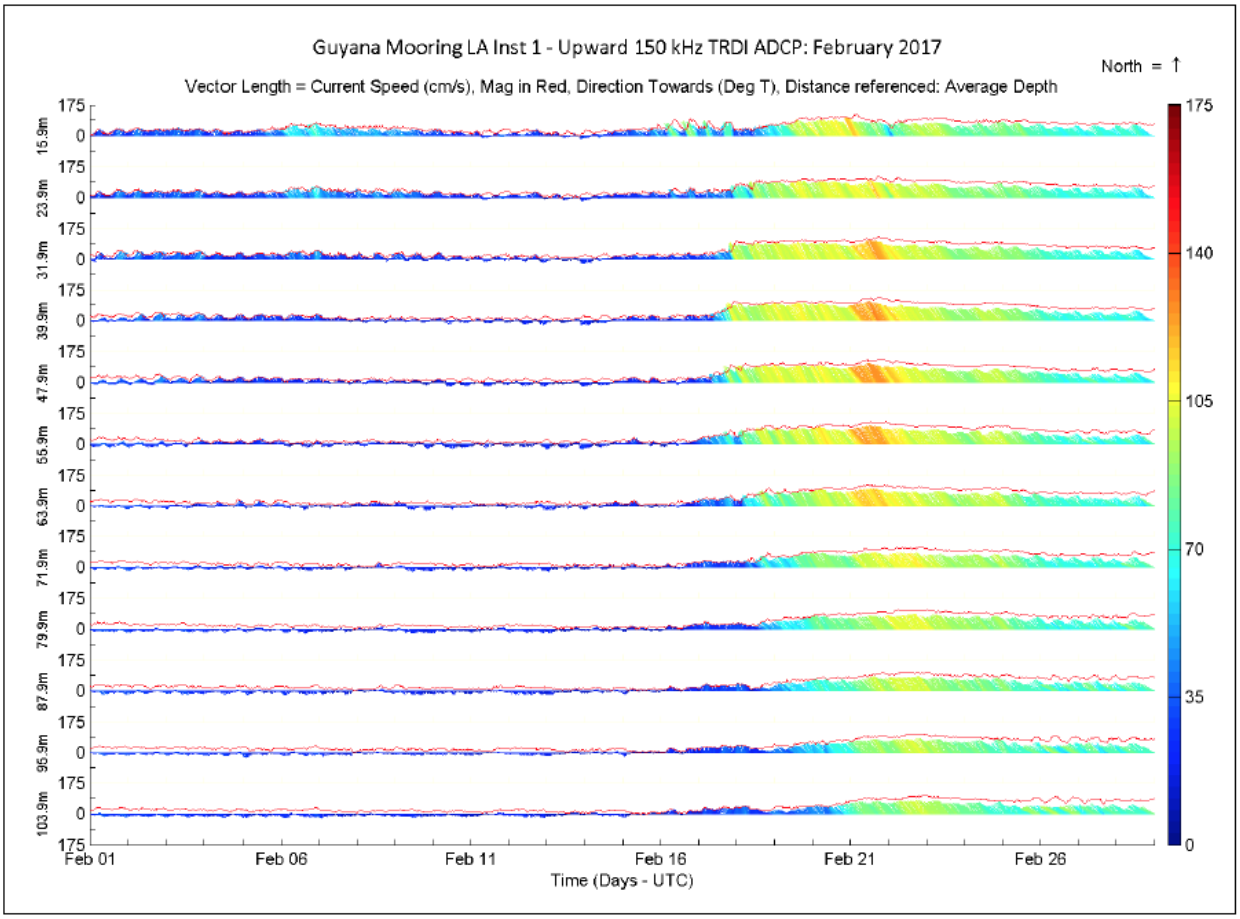


Source: TDI-Brooks 2014

m= meters

Note: Each “stick” (also called a vector) describes the direction, speed, and depth of a discrete measurement. The length of the vector is directly proportional to its speed (a scale is provided at the bottom of the plot). The depth of each measurement is provided on the y-axis. The direction of the vector points in the compass direction of the current flow (north corresponding to “up” on the plot). The horizontal distance between stations on the x-axis is to scale.

Figure 6.4-3: Vector Stick Plot for Stations on the Stabroek Block LADCP Transect



Source: RPS 2018a

ADCP = Acoustic Doppler Current Profile; kHz = kilohertz; Mag = magnitude; m = meters

Figure 6.4-4: Near Surface Currents at LF Mooring Buoy, Showing the Onset of the Strong NW-NNW Currents related to the NBC

6.4.2.2. Marine Water Quality

Regional Water Quality Influences

The hydrographic[14] and isohaline[15] conditions in Guyana's coastal marine waters are greatly impacted by the outflow of the coastal rivers in the region, as described in Section 6.4.2.1, Oceanographic Conditions. The large amount of freshwater discharge affects ocean salinity and temperature. Oceanic water is relatively heavy, cold, and saline compared to the lighter, warmer, and fresher water of the Amazon and Orinoco plumes that converge offshore of Guyana. These convergences form oceanic fronts offshore of Guyana. Freshwater lenses[16] generated by the Amazon and Orinoco rivers are transported across Guyana's continental shelf

[14] Relating to the characteristic features (such as flow or depth) of bodies of water

[15] Isohalines are areas in an aquatic system that have the same salinity.

[16] Freshwater lenses are formed near the surface of a marine environment when fresh (non-saline) water from rivers or rainfall enters a marine/saline waterbody. Freshwater is lighter and floats to the top of the saline water column, creating a layer (lens) of fresh, lower-salinity water.

to points north and west. These lenses persist for months and have been detected as far away as Barbados and Trinidad (Sherman and Hempel 2009).

Of the several coastal rivers that influence the Guyana offshore marine environment, the Amazon River, with an average discharge of 180,000 m^3 per second (Nittrouer and De Master 1987), is the most prominent factor in terms of marine water quality. Analysis of the Amazonian plume has shown there is little seasonal variation in the plume's nutrient content (e.g., silicates of 144 micromoles per kilogram [µmol/kg], phosphates of 0.7 µmol/kg, and nitrates of 16 µmol/kg) (De Master and Pope 1996). It has been estimated that 40 to 50 percent of the annual Amazon run-off transits along the coast of Guyana (Nittrouer and De Master 1987).

The entire region offshore of Guyana is considered part of the North Brazil Shelf LME. The ocean temperature in the North Brazil Shelf LME has alternately warmed and cooled over the last few decades. A period of cooling lasted from the mid-1970s through the mid-1990s; since the mid-1990s, the LME has consistently warmed (Sherman and Hempel 2009). The net change in the LME's water temperature since 1957 equates to an average increase of more than 0.22 ˚C (0.40 °F) over 50 years (Sherman and Hempel 2009).

Characterization of Water Quality in the Stabroek Block

Water quality data were collected from the Stabroek Block offshore Guyana as part of EBSs conducted in 2014 (Maxon and TDI-Brooks 2014), 2016 (Fugro 2016), 2017 (ESL 2018a), 2018 (Maxon et al. 2019; Fugro 2019a), 2019 and 2020 (Appendix I, Recent Environmental Baseline Survey Reports), and as part of the EBSs in the Canje Block in 2018 (Maxon et al. 2019). The full 2014, 2016, and 2017 EBS reports were appended to the Liza Phase 2 Development Project EIA; one of the 2018 EBS reports (Fugro 2019a) was focused on the Payara Development Project PDA and was appended to the Payara EIA. The 2019 and 2020 EBSs focused on the Hammerhead PDA (Appendix I, Recent Environmental Baseline Survey Reports). Figure 6.4-5 displays the combined water quality sampling locations for the EBS events. Descriptions of the sampling program for each survey and summaries of the results are provided below.

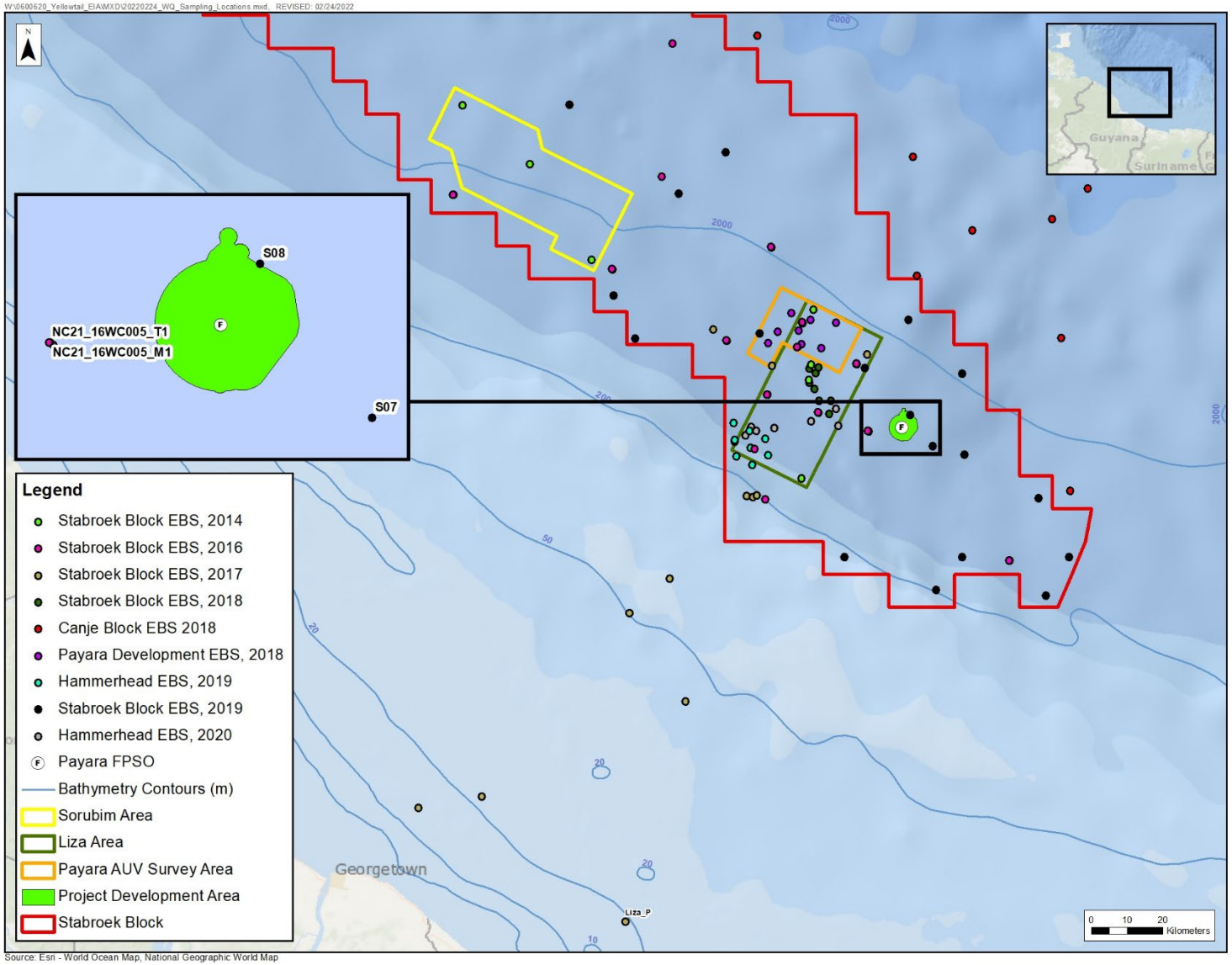


Figure 6.4-5: Combined Water Quality Sampling Locations—2014, 2016, 2017, 2018, 2019, and 2020 Surveys

2014 Survey

In the 2014 survey (Maxon and TDI-Brooks 2014), water quality sampling was conducted at four stations in the Liza field and three stations at a location approximately 100 kilometers (62 miles) northwest of the Liza field (referred to in the survey as the Sorubim area). Three discrete water samples were collected at each station: from the near-surface (5- to 10-meter [16.4- to 33-foot] depth), from the mixed layer (around 25-meter [82-foot] depth), and from approximately 5 to 10 meters (16.4 to 33 feet) above the seafloor, resulting in a total of 21 water samples. All samples were analyzed for total suspended solids (TSS), TOC, SHC, PAHs, and metals. Additionally, at each station, a vertical profile of water quality was characterized with a conductivity-temperature-depth (CTD) meter, augmented with additional sensors for dissolved oxygen (DO) and turbidity.

Water-column profiling depicted a steep halocline, reaching a maximum salinity of 37 parts per thousand (ppt) at 100-meter (328-foot) depth. Water temperature dropped from 28 °C at the surface to 3 °C around 2,000 meters (6,562 feet). The water column was highly stratified, likely limiting nutrient flux into surface waters from below the mixed layer. The permanent (non-seasonal) pycnocline[17] extends down to approximately 200 meters (656 feet), below which density increases slowly with depth. The water column was relatively clear, with light transmittance through the 25-centimeter (10-inch) path length typically greater than 95 percent. DO was consistently high, ranging from roughly 6 mg/L near the surface to greater than 8 mg/L in near-bottom waters.

Average TOC concentrations were 0.81 mg/L for both the Liza and Sorubim areas. Average TSS concentrations were 4.3 mg/L and 4.8 mg/L for the Liza and Sorubim areas, respectively.

Barium was the only metal detected in all samples. Copper, mercury, and zinc were the only other metals detected, with mercury concentrations (detected in 2 out of 21 samples) at less than 1 part per trillion. Arsenic, cadmium, chromium, and lead were not detected in any of the samples. Concentrations of all metals were well below those considered harmful to aquatic organisms in marine waters.

Total PAH concentrations (for 43 compounds) were extremely low in all samples (less than or equal to 50 nanograms per liter [ng/L]). The majority of detected PAH compounds were naphthalene, and C1- and C2-naphthalenes, suggesting the potential for trace-level introduction from the analytical laboratory (these compounds are ubiquitous laboratory contaminants). Total SHCs were detected in only 4 out of 21 samples, with the highest reported concentration at 230 micrograms per liter (µg/L) (Maxon and TDI-Brooks 2014).

2016 Survey

The 2016 survey provided additional data from an area covering 247 mi² (approximately 64,000 hectares). Water quality samples were collected at 15 locations in the Stabroek Block; at each location, samples were collected at top, middle, and bottom depths and samples were analyzed for TOC, TSS, hydrocarbons, PAHs, and metals. Additionally, the water column was

[17] A layer in a body of water in which water density increases rapidly with depth

profiled at each station with a CTD meter, augmented with additional sensors for DO, pH, and turbidity.

Water profiling at all sampling stations identified a generally stratified water column, with depth of thermocline[18], halocline[19], and oxygen boundary[20] increasing with water depth. At all 15 stations, temperature, salinity, and DO displayed a strong thermocline, halocline, and oxygen boundary. Salinity exhibited a narrow range, with a maximum value of 37.05 ppt. Surface temperatures were relatively consistent across stations, but the lower water column temperatures decreased proportionally with water depth. The mean surface temperature was 27.8 °C (82 °F), and the mean bottom temperatures ranged from 2.7 °C (36.9 °F; deepest site) to 11.2 °C (52.2 °F; shallowest site). Turbidity within the water column remained reasonably constant throughout the entire length of all water profiles, with mean values equal to or less than 2.9 Formazine Turbidity Units (FTU). At all stations, the pH (which ranged between 8.18 and 8.47) increased gradually with increasing depth, and pH profiles were very similar between stations.

TOC and TSS concentrations were generally low at all stations, with TOC concentrations decreasing slightly overall with depth from a mean surface concentration of 2.3 mg/L to a mean bottom concentration of 1.8 mg/L. TSS concentrations exhibited a similar profile, with a mean surface concentration of 6.7 mg/L and a mean bottom concentration of 3.4 mg/L.

THC concentrations and PAH concentrations were generally at low levels across the survey area, with little variation between samples (highest reported THC concentration of 35.9 µg/L and highest reported total PAH concentration of 20.6 ng/L).

Reported metal concentrations were low in all water samples and did not vary substantially between stations or with depth. Metals reported above detection limits included cadmium, chromium, copper, lead, zinc, and arsenic; concentrations of all detected metals were low.

2017 Survey

The 2017 survey included sampling at 12 additional locations along the continental shelf, along the continental slope, and within the Stabroek Block. Samples were collected at surface, mid-depth, and bottom, for a total of 72 samples (duplicates of each were collected). Samples were analyzed for TOC, TSS, total dissolved solids (TDS), chemical oxygen demand (COD), SHCs, metals, cyanide, and ammonia. Additionally, the water column was profiled at each station with a CTD meter, augmented with additional sensors for DO and turbidity.

[18] A thermocline is the location within a stratified water column where a steep gradient of temperature exists. Typically, a thermocline marks a transition layer between a warmer (and mixed) surface layer and a cooler deep layer.
[19] Similar to a thermocline, a halocline is the location within a stratified water column where a steep gradient of salinity exists. Typically, a halocline marks the transition layer between a fresher surface layer and more saline deep layer.
[20] An oxygen boundary develops due to the presence of a thermocline and/or halocline, which reduce oxygen transport across these transition layers. Across the oxygen boundary, a sharp gradient in DO exists where the layer near the surface is typically well mixed and near saturation due to re-aeration, whereas the layer below reaches anoxic (very low DO) conditions.

Depths profiled for temperature and salinity revealed the presence of a thermocline and halocline at the deepwater stations (1,705 to 2,006 meters [5,594 to 6,581 feet]) and well-mixed conditions at the continental shelf stations (14 to 26 meters [46 to 85 feet]) and continental slope stations (134 to 215 meters [440 to 705 feet]). The strengths (gradient) of these profiles were consistent with the data collected in 2014 and 2016. The range of temperatures observed near the surface was also consistent with previous observations. DO ranged from 6.21 mg/L to 6.86 mg/L at shelf stations, 6.23 mg/L to 8.05 mg/L at slope stations, and 6.28 mg/L to 10.56 mg/L at deepwater stations.

TDS, TSS, TOC, and COD showed decreases in concentrations at deeper locations. In general, TDS concentrations were highest at the top of the water column and lowest at the middle. The average TDS concentration decreased with increasing distance from the shore. TOC concentrations were similar but tended to decrease with increasing depth, ranging between 1.3 mg/L and 2.1 mg/L at the surface and between 1.1 mg/L and 1.9 mg/L in the bottom depths. TSS concentrations also generally decreased with increasing depth, ranging between 2.8 mg/L and 28 mg/L near the surface and between 3.3 mg/L and 10.6 mg/L in the bottom depths. COD concentrations also generally decreased with increasing depth, with the average values at the top being approximately 1.5 times higher than the average values at the bottom.

Total cyanide and all analyzed metals were reported to be not detected in all samples. SHCs were detected at all of the slope and shelf locations, but not at the deepwater stations. Reported detections ranged from 210 to 580 µg/L. Ammonia was detected only at shelf locations, with reported detections ranging from 0.01 mg/L to 0.02 mg/L (ESL 2018b).

2018 Stabroek Block (Liza Phase 2) Survey

Eight water profiles and 24 discrete samples (8 stations x 3 depths) were sampled within the Liza Phase 2 Development area in 2018. Water column profiling depicted a steep halocline, reaching a maximum salinity of 37 ppt at approximately 100-meter depth at all stations. A warm water layer (approximately 30 ºC [86 ºF]) was detected on top of a prominent thermocline at 40-to 50-meter depth, below which temperature was observed to drop monotonically from 28 to 3 ºC (82.4 to 37.4 ºF) around a depth of 1,600 meters (5,249 feet). The resulting density profiles indicated a highly stratified water column, which likely limits nutrient flux into surface waters from below the mixed layer. The permanent (non-seasonal) pycnocline extended down to approximately 200 meters (656 feet), below which density increased slowly with depth. The water column was relatively clear, with turbidity less than 1 Nephelometric Turbidity Units (NTU) throughout the water column. DO was consistently high, ranging from roughly 6 mg/L near the surface to greater than 7.5 mg/L below 1,000 meters (3,281 feet), although concentrations dropped to 4 mg/L between 100- and 1,000-meter (328- and 3,281-foot) depth.

TOC concentrations in all samples were low (less than or equal to 1.2 mg/L), commensurate with TOC concentrations measured in an open ocean water sample collected from the Gulf of Mexico for quality control purposes. Values for pH were within the normal, narrow range for seawater (a well-buffered system) with no differences between sampling depths within or across sampling years.

All 11 metals, including barium, were detected in eight or more samples, well within the natural range for ocean water. Concentrations for the majority (7 of 11) of metals did not vary significantly between depth strata. There were no detectable concentrations of either resolved or unresolved TPH (less than 13.3 µg/l). Extremely low concentrations of total PAH_{44} (sum of 44 PAH analytes) were detected in all samples (less than or equal to 15 ng/L); however, results were attributed to ultra-trace level laboratory contamination, as indicated by corresponding detections in method blank samples.

2018 Payara Survey

The 2018 Payara survey included sampling at eight additional locations within the Payara PDA. Samples were collected at the surface (10 meters [33 feet]), below the thermocline (approximately 200 meters [656 feet] below surface), and near the bottom of the water column (20 meters [66 feet] above seabed), for a total of 24 samples. Samples were analyzed for TSS, TOC, hydrocarbons, and metals. Additionally, the water column was profiled at each station with a CTD meter, augmented with additional sensors for DO, pH, and turbidity.

Depths profiled for temperature and salinity revealed the presence of a thermocline and halocline at these stations. The strengths (gradient) of these profiles were consistent with the data collected at deeper stations in 2014 and 2016. The range of temperatures observed near the surface was also consistent with previous observations where surface temperatures were around 29.3 ºC (84.7 ºF) near surface and around 3.7 ºC (38.7 ºF) near seabed. Salinity ranged from 34.6 ppt to 36.9 ppt, with a mean of 35 ppt. DO was reported as a percentage of saturation and ranged from 33.2 percent to 105 percent, with a mean of 49.1 percent. pH showed alkaline conditions throughout the survey area, with a range of 7.60 to 8.43, and a mean of 7.77.

Reported TSS concentrations did not exhibit any significant variation with depth. In surface samples, TSS concentrations ranged from 22.9 mg/L to 56.1 mg/L; in mid-depth samples, concentrations ranged from 25.0 mg/L to 58.6 mg/L; and in the bottom-depth samples, concentrations ranged from 25.4 mg/L to 49.6 mg/L. All TOC concentrations were below the minimum reporting value of 0.5 mg/L, lower than for previously sampled stations.

Reported THC concentrations were below the minimum reporting value of 10 µg/L at all stations except for one (bottom), which had a reported concentration of 21 µg/L. This value of 21 µg/L was higher than the mean THC concentration reported for previous surveys. Arsenic concentrations ranged from 1.42 µg/L to 2.19 µg/L, with a mean concentration of 1.7 µg/L (comparable to previous surveys). All other metals were also found to be within the same range as previously sampled.

2018 Canje Survey

The 2018 Canje Block survey included sampling at eight locations for the Canje Block Offshore Guyana. Seawater samples were analyzed for conductivity/salinity, temperature, DO, turbidity, and depth.

A lens of relatively low salinity (approximately 33 ppt) water was found to transition to a steep halocline, reaching a maximum of 37 ppt approximately 100 meters (328 feet) at all stations.

A warm water layer (approximately 30 ºC [86 ºF]) was found to sit on top of a prominent thermocline at 40- to 50-meter (131- to 164-foot) depth, below which temperature dropped monotonically to 3 ºC (37.4 ºF) around 2,000 meters (6,562 feet). The resulting density profiles indicated a highly stratified water column, which likely limits nutrient flux into surface waters from below the mixed layer (approximately 30- to 38-meter [98- to 125-foot] depth). There was a sharp increase in density at the 100-meter (328-foot) salinity maximum in most profiles. The permanent (non-seasonal) pycnocline extended down to approximately 200 meters (656 feet), below which density increased slowly with depth.

Turbidity was extremely low (less than 0.5 NTU) across profiles and throughout the water column, consistent with open ocean conditions removed from impacts from surface water runoff or hydrodynamic transport of suspended material.

TOC concentrations were the highest at the surface (mean = 0.94 ± 0.06 mg/L) and decreased with depth to a minimum in near-bottom waters (mean = 0.47 ± 0.05 mg/L). Observed concentrations were typical of low nutrient, tropical Atlantic Ocean water (Hansell and Carlson 2001).

Changes in ocean waters are strongly linked to light levels, which influence both the rate and depth distribution of photosynthesis, a primary consumer of CO_2. As expected, pH was highest (mean = 8.44 ± 0.04) at the surface and decreased with depth to a minimum (mean = 8.14 ± 0.04) near the seafloor, where there is typically not enough light to support photosynthesis and respiration (CO_2 production) dominates. TOC and pH results were within the range of tropical offshore ocean water (Sarmiento and Gruber 2006).

PAH and TPH were measured as general indicators of petroleum-related contamination. There were no detectable concentrations of either resolved or unresolved TPH (less than 13.3 µg/L). Total PAH concentrations (based on either the sum of 44 [total PAH_{44}] or 16 [total PAH_{16}] priority pollutant analytes) were extremely low in all samples (less than or equal to 7.61 ng/L). However, the only PAH compounds detected were naphthalene, C1-naphthalene, phenanthrene, and benzo(a)pyrene. Naphthalene is a ubiquitous trace-level laboratory contaminant, often introduced from polyvinyl chloride tubing and laboratory equipment. Evidence of ultra-trace naphthalene contamination from the laboratory also is derived from the fact that concentrations were detected across depths (including mid-depth samples) and in the corresponding method blank.

Phenanthrene and benzo(a)pyrene are ubiquitous PAHs found in all petroleum and its products, and in combusted fuels; however, ultra-trace benzo(a)pyrene (2.29 ng/L) was also detected in the method blank. Detection of phenanthrene and benzo(a)pyrene in the absence of a full-range of other PAH indicates airborne combustion-related particulates as a possible source.

2019 Stabroek Block Survey

During the 2019 Stabroek Block survey, a series of 20 water column physical profiles were collected, recording salinity, temperature, density, DO, and turbidity. At each of these 20 sample stations, three discrete water samples were collected. Samples were collected near the surface (2- to 4-meter [7- to 13-foot] depth), mid-water (base of the mixed layer, 34- to 69-meter [112- to

226-foot] depth), and near-bottom (generally 4- to 60-meters [13- to 197-foot] above the seabed). Samples were analyzed for a suite of metals, TOC, TSS, TPH, and PAHs.

The water column profiles showed that there was a lens of lower salinity water (approximately 33 ppt) in the top 5 meters (16 feet) of the water column, giving way to higher salinities with a steep halocline (reaching a maximum of 37 ppt) at a depth of approximately 80 meters (263 feet). Between this depth and approximately 200 meters (656 feet) there was a strong pycnocline (increase in water density), below which the water density increased more gradually with depth.

The maximum surface water temperature was 27.8 ºC (82 ºF), decreasing with depth to a minimum of 2.83 ºC (37.09 ºF) at 2,665 meters (8,743 feet). Surface DO levels were generally in the 5 to 6 mg/L range, reaching a minimum of 3.1 mg/L at 290 meters (951 feet) and a maximum range of 7 to 8 mg/L below approximately 1,000 meters (3,281 feet). Turbidity data showed that the water column was clear (less than 1 NTU) apart from just above the pycnocline, likely attributed to accumulation of settled particles or phytoplankton concentrations related to nutrient levels.

Of the 12 metals analyzed, all except mercury and selenium were detected in one or more samples. Five metals (arsenic, barium, copper, lead, and nickel) were detected in all 60 samples. The concentrations were within the natural ranges for seawater, and there was little variation between stations and no significant differences in mean concentrations between water depths.

The concentrations of TOC in all 60 samples were low (less than or equal to 1.03 mg/L) with the highest concentrations in the surface samples and mixed layer samples, likely related to the concentrations of phytoplankton density in these water layers. TSS concentrations indicated mostly clear water, consistent with open ocean background conditions, with concentrations greater than 30 mg/L in only 4 of 60 samples.

There were no detectable concentrations of TPH in any of the water samples, and concentrations of the only PAHs detected (naphthalene and/or phenanthrene) were very low in all samples (less than 3 ng/L). These PAHs were also recorded in the field blanks, indicating possible sample handling/laboratory contamination.

2019 Hammerhead Survey

As part of a larger seabed video and box core survey, a series of eight water column profiles and water quality samples were collected. A multi-parameter probe was used to measure conductivity, temperature, depth, turbidity, DO saturation, and pH with depth. Water samples were collected at near-surface (5-meter [16-foot] depth), mid-water below the thermocline, and 10 meters (33 feet) above the seabed and analyzed for metals, TSS, TOC, and THC.

The water profiles obtained at all stations were typical of the oceanic water column within the region. There was an upper layer of wave-mixed water, extending to approximately 20-meter depth, where all parameters remained relatively constant. Beyond this, there was a distinct thermocline, extending to approximately 200-meter (656-foot) depth, over which temperature

and DO concentration decreased rapidly. Temperatures ranged from 27.9 °C (82.2 °F) at the sea surface to 5 °C (41 °F) near the seabed. DO saturation ranged from 108 percent near the surface, decreasing to approximately 40 percent by approximately 300-meter (984-foot) depth at all stations.

Salinity showed an initial trend of increase, followed by a decrease below approximately 200 meters (656 feet), below which it remained fairly constant. Mean salinity at near surface waters was 34.4 Practical Salinity Units (PSU), increasing to 36.9 PSU and then decreasing to 35 PSU below 200 meters (656 feet) to the seabed.

Measured pH values were alkaline throughout the survey area and ranged from 7.75 to 8.28, with a mean of 7.33. Values of approximately 8.3 were recorded at the surface to depths and decreased to approximately 7.8 by 200 meters (656 feet). Turbidity was consistently low throughout the water column (0.513 FTU to 2.54 FTU across the survey area, with a mean value of 1.7 FTU).

Water samples from the survey area were analyzed for key indicators of water quality including ammoniacal nitrogen, nitrate, nitrite, total Kjeldahl nitrogen (TKN), TOC, and TSS concentrations. Mean ammoniacal nitrogen and nitrate concentrations provided little evidence of stratification with sample depth. Nitrite and TKN concentrations were below their MRVs (less than 0.01 mg/L and less than 2 mg/L, respectively) at all depths at all stations sampled within the survey area. The mean TOC concentrations provided little evidence of stratification with sample depth. Values ranged from 0.93 mg/L to 2.16 mg/L. The mean TOC concentrations observed were higher than those observed in the Payara survey area (Fugro 2019b), but lower than the mean values recorded at the Liza field survey (Fugro 2016) at comparable depths. TSS concentrations showed little evidence of stratification with sample depth. Mean TSS concentrations ranged between 25.6 mg/L to 108 mg/L. The mean TSS concentrations observed were higher than those from the Payara survey (Fugro 2019b) and the Liza field survey (Fugro 2016) at comparable depths.

2020 Hammerhead Survey

The 2020 Hammerhead survey included sampling at eight locations. Seawater samples were analyzed for TOC, TSS, hydrocarbons, and metals. Additionally, the water column was profiled at each sampling station within the study area for conductivity/salinity, temperature, DO, turbidity, and pH.

Salinity ranged from 34.54 to 37.2 PSU during the survey, with similar trends at each station. Temperature ranged from 4.07 °C to 28.19 °C (39.33 to 82.74 °F) during the survey and had a similar trend at each station. Temperature changed very little in the upper 60 to 70 meters (197 to 230 feet) of the water column. DO concentration ranged from 3.90 to 8.47 mg/L (mean of 5.17) during the survey and DO saturation ranged from 40.78 percent to 105.49 percent, with a mean of 56.41 percent.

Turbidity within the water column remained reasonably constant throughout the entire length of all water profiles, with mean values equal to or less than 0.25 NTU. The pH was generally stable throughout the water column, ranging from 8.07 to 9.62, and a mean of 8.4.

TOC concentrations were very low at all EBS stations and were detectable in the surface water, with a range from 0.3 mg/L to less than or equal to 0.2 mg/L. TSS concentrations were low in the survey area, with most samples below the analytical laboratory reporting limits of 5 mg/L.

TPH concentrations at all sampling stations and depths were below the analytical detection limit of 13 µg/L. Total PAH concentrations (for 64 compounds) were extremely low in all samples, ranging from non-detect to 24.1 ng/L.

Total metal concentrations within the water column were low with the exception of strontium and molybdenum. Strontium, one of the most abundant minerals in seawater, was at expected levels of around 8,000 µg/L. Concentrations of molybdenum ranged from 10.3 to 35 µg/L, which was elevated above the expected range in open ocean systems of 9.3 to 10.4 µg/ L (Smedley and Kinniburgh 2017). Total aluminum and beryllium concentrations were below the analytical laboratory's reporting limit of 21 µg/L and 0.02 µg/L, respectively.

6.4.3. Impact Assessment—Marine Water Quality

This section addresses potential impacts on marine water quality resulting from planned Project activities. The potential impacts assessed include changes to marine water quality physico-chemical conditions as a result of the various effluent discharges associated with the Project. The following sections describe the various discharges for which potential marine water quality impacts were assessed, the application of computational models for impact magnitude quantification, and a discussion of the significance of potential impacts.

6.4.3.1. Relevant Project Activities and Potential Impacts

Planned discharges of drill cuttings and fluids may have a localized impact on marine water quality as a result of increased TSS concentrations in the water column. Cuttings and fluids released at the seafloor during jetting and drilling of the initial sections of the well will temporarily increase TSS concentrations around the well near the seafloor. Cuttings discharged overboard from the drill ships after treatment will temporarily increase TSS concentrations in the photic zone (the upper portion of the water column). These temporary increases in TSS may have indirect impacts on marine biota through clogging of fish gills or, in the photic zone, causing light inhibition for photosynthetic organisms.

During installation, commissioning, and start-up of SURF equipment, hydrotesting fluids containing biocides, oxygen scavengers, and corrosion inhibitors, as well as hydrate-inhibiting fluid (such as methanol or ethylene glycol), will be discharged to the sea, resulting in temporary, localized changes to water quality.

The FPSO will have several discharges related to its operation and maintenance during production operations. The potential impacts from these discharges include localized changes to water quality from effluent discharges during production operations, and localized changes to water temperature from discharge of cooling water effluent and treated produced water.

Table 6.4-2 summarizes the Project stages and activities that could result in potential Project impacts on marine water quality. Modeling of potential impacts was focused on the drilling, installation/commissioning/start-up, and production operations discharges described above. Other effluent discharges from drill ships, marine installation, decommissioning, and support vessels (e.g., food wastes, sewage, bilge water, etc.) will be treated and/or discharged in accordance with applicable international standards and the impacts of these discharges will be negligible.

Table 6.4-2: Summary of Relevant Project Activities and Key Potential Impacts—Marine Water Quality

Resource/Receptor	Stage	Project Activity	Key Potential Impacts
Marine water quality (marine fauna as receptors)	Development Well Drilling SURF/FPSO Installation, Commissioning, and Start-up	Discharge of drill cuttings, resulting in increased TSS concentrations in water column Discharge of liquid effluents from drill ships and marine installation and support vessels (chemical substances) Discharge of hydrotesting fluids	• Increased TSS concentrations in water column (indirect impacts on marine biota) • Increased chemical concentrations in water column
	Production Operations	Discharge of liquid effluents from FPSO and marine support vessels (chemical substances, and elevated-temperature streams)	• Increased chemical concentrations in water column (indirect impacts on marine biota) • Increased temperature in water column (indirect impacts on marine biota)
	Decommissioning	Discharge of liquid effluents from marine support vessels (chemical substances)	• Increased chemical concentrations in water column (indirect impacts on marine biota)

6.4.3.2. Characterization of Impacts—Increased TSS from Drill Cuttings Discharge

Magnitude of Impact—Increased TSS Concentrations from Drill Cuttings Discharge

The assessment of the Project's magnitude of potential impacts from the increase of TSS concentrations from drill cuttings discharge is determined based on consideration of geographic extent, intensity, frequency, and duration. The intensity of potential impacts on water quality related to changes in TSS concentration is defined according to the definitions provided in Table 6.4-3. These definitions consider the potential indirect impacts on marine biota.

Table 6.4-3: Definitions for Intensity Ratings for Potential Impacts on Water Quality from Increases in TSS Concentrations

Criterion	Definition
Intensity	Negligible: No TSS concentrations above levels with potential to contribute to health impacts on marine fauna
	Low: TSS concentrations above levels with potential to contribute to health impacts on marine fauna, but limited to a localized area (i.e., within the PDA)
	Medium: TSS concentrations above levels with potential to contribute to health impacts on marine fauna over a moderately sized area (i.e., up to 5 km beyond the PDA)
	High: TSS concentrations above levels with potential to contribute to health impacts on marine fauna, affecting a widespread area (i.e., more than 5 km beyond the PDA)

km = kilometer

As described in Appendix C, Water Quality Modeling Report, modeling of discharge and deposition of cuttings was performed using the GEMSS model. This 3D particle-based model uses Lagrangian algorithms in conjunction with currents, specified mass load rates, release times and locations, particle sizes, settling velocities, and shear stress values to calculate the fate and transport of discharged drill cuttings. Model outputs provide estimates of the water column TSS concentrations resulting from the planned drilling operations.

For the purpose of modeling TSS concentrations, a total of eight drill cuttings deposition scenarios were modeled: two scenarios at Drill Center DC-I (the shallowest of the Project drill centers) and two scenarios at Drill Center DC3-P (the deepest of the Project drill centers), with each of those four scenarios under two current conditions—the minimum and the maximum of the monthly averaged and depth-averaged current speeds. The current speeds were derived from the SAT-OCEAN ocean circulation model. The modeled deposition scenarios reflect combinations of top-hole section drilling (containing WBDF) with cuttings discharged at the seafloor, and bottom-hole drilling (containing NADF cuttings) with cuttings discharged overboard from the drill ship following treatment, per good international oilfield practice—each for multiple wells within a single drill center cluster (World Bank 2015).

As was assumed with drill cutting deposition modeling (Section 6.3.3, Impact Assessment—Marine Geology and Sediments), modeling of increases in water-column TSS concentrations was conducted assuming cuttings from the open-hole sections (containing WBDF) will be discharged at the seafloor. This was confirmed to be a conservative assumption, as modeling indicated the highest predicted TSS concentration increases are associated with discharge of cuttings at the seafloor (see results discussion below).

Modeling of cuttings discharge and deposition indicates the maximum instantaneous TSS concentrations at the seafloor during drilling of the initial sections of the well will be between approximately 8,412 mg/L and 55,939 mg/L, depending on currents, drill center location, and drilling scenario. These concentrations correspond to only the initial sections of the well, where WBDF and cuttings are discharged directly from the casing at the seabed. In contrast, modeling indicates the maximum instantaneous TSS concentrations in the upper portion of the water column to be between approximately 21.3 mg/L and 1,013 mg/L, depending on currents, drill

center location, and drilling scenario. These predicted concentrations are much lower because drill cuttings and fluids from bottom-hole sections that are released near the surface will be processed on the drill ship to remove a substantial amount of the NADF prior to discharge. Additionally, discharges near the surface are also subjected to greater mixing from the higher current speeds at the shallower depths.

A TSS threshold of 35 mg/L (geometric mean) is recommended by the International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) (IMO 2006) for discharges of effluent from marine vessels. This threshold was used to assess the extent of the area with the potential to reduce water quality (with associated indirect impacts on marine biota, either through gill fouling or through inhibited photosynthesis via a reduction in light penetration). Table 6.4-4 summarizes the results of the TSS concentration modeling for the drill cuttings discharge scenarios described above.

Modeling predicts that TSS concentrations above the 35 mg/L threshold will occur mostly during drilling of the initial well sections, and these instances are confined to within a localized area around the well locations, near the seafloor. It is noted that these water depths are too great to allow for light penetration, so potential photosynthesis impacts at these depths are not a concern. In the case of bottom-hole well sections involving overboard cuttings discharges, only slight exceedances above the TSS threshold of 35 mg/L are predicted to occur near the surface, over a very localized area.

Table 6.4-4: Summary of TSS Concentration Modeling Results for Drill Cuttings Discharge Scenarios

Scenario [a] / Drill Center	Maximum TSS (mg/L) Bottom / Surface	Area (km²) with TSS > 35 mg/L Threshold Bottom / Surface
Scenario 1—DC1-I Minimum Currents	52,248 / NA	0.400 / NA
Scenario 1—DC1-I Maximum Currents	43,854 / NA	0.991 / NA
Scenario 1— DC3-P Minimum Currents	55,939 / NA	0.0811 / NA
Scenario 1— DC3-P Maximum Currents	33,152 / NA	0.068 / NA
Scenario 2—DC1-I Minimum Currents	18,717 / 951.9	0.240 / 0.012
Scenario 2—DC1-I Maximum Currents	33,233 / 87.74	0.366 / 0.023
Scenario 2—DC3-P Minimum Currents	14,711 / 1,013	0.207 / 0.0134
Scenario 2—DC3-P Maximum Currents	8,412 / 21.3	0.187 / NE

NA = not applicable (no surface discharges for Scenario 1); NE = no exceedance [of the 35 mg/L threshold]
[a] Scenario 1 reflects seabed discharges from sequential jetting/drilling of two top-hole sections (sections 1 and 2) at each of four well locations at a drill center using WBDF, with discharges of cuttings at the seabed. Scenario 2 reflects seabed discharges from sequential jetting/drilling of two top hole sections (sections 1 and 2) at two well locations at a drill center using WBDF, with discharges of cuttings at the seabed, followed by drilling of bottom-hole sections (sections 3 and 4) of the second well with NADF, with overboard discharges of treated cuttings.

Considering the results of the modeling discussed above, the impacts will be limited to the portions of the **Direct AOI** in the immediate vicinity of the drill centers. While TSS concentrations for discharges at the seafloor will result in conditions exceeding the threshold, modeling indicates TSS concentrations will be reduced to below the threshold through settling and dispersion within approximately 12 hours of cessation of drilling for each well section (0.5 to 1.5 days, with approximately 1-day breaks in discharge between sections). TSS concentrations will be reduced to below the threshold within approximately 2 hours of cessation of drilling for bottom-hole sections. While this illustrates the intermittent nature of the impact, drilling operations will occur on a relatively continual basis throughout the drilling stage. Based on this, the frequency designation is conservatively considered to be **Continuous** for the drilling stage. The impact itself will persist for less than a year in aggregate at each individual well, but development drilling across the Project will continue for more than a year, yielding a duration rating of **Long-term**. While there will be exceedances of the threshold, most of the area experiencing an exceedance of the 35 mg/L threshold will be near the bottom, where photosynthesis impacts are not relevant (as this depth is below the photic zone). The impacted portion of the photic zone near the surface covers a very small area, entirely within the PDA. The impacted area near the bottom is concentrated around the wells, predominantly within the PDA, with some modeled instances where TSS concentrations may extend slightly outside of the PDA. Considering these factors, the intensity of the impact is considered to be **Medium**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude of impact on water quality from increases in TSS concentrations is therefore considered **Medium** (see Table 6.4-5)**.**

Table 6.4-5: Magnitude Ratings for Potential Impacts on Water Quality from Increased TSS Concentrations

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Development well drilling	Marine water quality (marine fauna) – elevated TSS concentrations	Direct AOI	Medium	Continuous	Long-term	Medium

Sensitivity of Resource—Increased TSS Concentrations from Drill Cuttings Discharge

The definitions used to designate sensitivity of receptors to increases in TSS concentrations are shown in Table 6.4-6. The direct impacts of increases in TSS are to water quality. As this can have an indirect impact on marine biota, the sensitivity of these receptors has been taken into account in assigning the level of sensitivity. Impacts on marine biota are discussed in Section 7.8, Marine Fish, and Section 7.9, Marine Benthos.

Table 6.4-6: Definitions for Receptor Sensitivity Ratings for Potential Impacts of Increased TSS Concentrations

Criterion	Definition
Sensitivity	Low: Affected portion of water column does not support high densities of unique, biologically vulnerable, or otherwise critically important species.
	Medium: Affected portion of water column supports high densities of unique, biologically vulnerable, or critically important species, but represents only a small portion of the area on which these species depend.
	High: Affected portion of the water column supports high densities of unique, biologically vulnerable, or critically important species, and represents a substantial portion of the area on which these species depend.

Based on the definitions above, the sensitivity of the overall marine water quality resource (considering sensitivity of potentially indirectly impacted marine biota) to increased TSS concentrations is considered **Low**, as the water column in which drill cuttings will be discharged does not support high densities of unique marine species. These ecological communities are discussed further in Section 7.8, Marine Fish, and Section 7.9, Marine Benthos.

Impact Significance—Increased TSS Concentrations from Drill Cuttings Discharge

Based on the magnitude of impact and resource sensitivity ratings, the significance of potential impacts on marine water quality from increased TSS concentrations resulting from drill cuttings discharge is considered **Minor**.

6.4.3.3. Characterization of Impacts—Changes to Water Quality and Temperature

Magnitude of Impact—Changes to Water Quality and Temperature

The assessment of the Project's magnitude of potential impacts on changes to water quality and temperature is determined based on consideration of geographic extent, intensity, frequency, and duration. The intensity of potential impacts on water quality is defined according to the definitions provided in Table 6.4-7. These definitions consider the potential indirect impacts on marine biota. The following paragraphs discuss the characteristics of the potential impacts from changes to water quality and temperature, and the resultant magnitude rating.

Table 6.4-7: Definitions for Intensity Ratings for Potential Impacts from Changes to Water Quality and Temperature

Criterion	Definition
Intensity	Negligible: No concentrations or temperature increases above levels with potential to contribute to health impacts on marine fauna
	Low: Concentrations or temperature increases above levels with potential to contribute to health impacts on marine fauna, but limited to a localized area (i.e., within the PDA)
	Medium: Concentrations or temperature increases above levels with potential to contribute to health impacts on marine fauna over a moderately sized area (i.e., up to 5 km beyond the PDA)
	High: Concentrations or temperature increases above levels with potential to contribute to health impacts on marine fauna, affecting a widespread area (i.e., more than 5 km beyond the PDA)

km = kilometer

Project Discharges

The Project will include several discharges with the potential to change water quality and temperature. These discharges, with estimated characteristics and volumes based on the preliminary Project design information, are listed in Table 6.4-8.

Table 6.4-8: Summary of Project-Related Discharges

Type of Discharge and Effluent Characteristics [a]	Estimated Discharge Volume/Rate [a]	Discharge Criteria	Treatment Required to Meet Criteria?
Drilling Related Discharges			
Production/injection well drilling	Approximate range: 6,822 bbl–7,052 bbl (1,091.5–1,128.3 m^3) (total discharged cuttings volume) Approximate range: 10,812 bbl–10,996 bbl (1,729.9–1,759.4 m^3) (total discharged drilling fluid volume)	NABF retained on discharged cuttings will not exceed 6.9 percent (by mass) on average. MARPOL 73/78 TSS guidance value of 35 mg/L in receiving waters.	Yes
SURF and FPSO Installation/Commissioning Discharges			
Ballast water (FPSO initial deballasting)	≤ 550,000 bbl (≤ 87,500 m^3) total	Perform discharge in accordance with IMO requirements	No
Hydrostatic test water • Biocide / oxygen scavenger / corrosion inhibitor: assumed concentration of 1,500 ppm[21]	65,000 bbl (10,400 m^3)(total volume for all flowlines and risers, occurring throughout SURF commissioning phase)	No visible oil sheen on receiving water	No

[21] Concentrations are assumed for the purpose of the EIA; final decisions will be made based on EEPGL selection process.

Type of Discharge and Effluent Characteristics [a]	**Estimated Discharge Volume/Rate** [a]	**Discharge Criteria**	**Treatment Required to Meet Criteria?**
Gas re-injection line commissioning Fluids • Hydrate inhibitor (e.g., methanol or ethylene glycol)	1,400 bbl (223 m^3) total	None	NA
Production Discharges			
Produced water • Oil and grease • Temperature (55 °C [131 °F] at point of discharge) • Residual production and water treatment chemicals: – Assumed scale inhibitor concentration ≤100 ppm[21] – Assumed corrosion inhibitor concentration ≤200 ppm[21] • Hydrate inhibitor (e.g., methanol) [c]	≤ 300,000 BPD (≤ 47,700 m^3 per day)	Oil in water content: 29 mg/L (monthly average); 42 mg/L (daily maximum) Temperature rise <3 °C (5.4 °F) at 100 meters (328 feet) from discharge	Yes
Cooling water • Assumed hypochlorite concentration: ≤ 5 ppm • Temperature (50°C [122 °F] at point of discharge)	≤ 1,900,000 BPD (≤ 302,100 m^3 per day)	No visible oil sheen on receiving water Temperature rise <3°C (5.4 °F) at 100 meters (328 feet) from discharge	No
Sulfate Removal, Ultrafiltration and Wash Water Processing Brines • Assumed hypochlorite concentration: ≤ 1 ppm[21] • Assumed electrolyte concentration: ≤ 1 ppm[21] • Assumed biocide concentration: ≤ 5 ppm[21] • Assumed oxygen scavenger concentration: ≤ 10 ppm[21] • Assumed scale inhibitor concentration: ≤ 5 ppm[21]	≤ 315,000 BPD (≤ 50,100 m^3 per day)	None	NA
Subsea hydraulic fluid discharge • Water soluble, low-toxicity	≤ 5 BPD (≤ 0.8 m^3 per day)	None	NA
FPSO bilge water	1,800 BPD (287 m^3 per day)	Oil in water content: <15 ppm	Yes
Inert gas generator cooling water	Negligible	None	NA
FPSO slop tank water (includes off-specification oil from process and deck drainage)	Slop tank water is rainfall-dependent, but expected to be negligible [b]	Oil in water content 29 mg/L (monthly average); 42 mg/L (daily maximum)	Yes

Type of Discharge and Effluent Characteristics [a]	Estimated Discharge Volume/Rate [a]	Discharge Criteria	Treatment Required to Meet Criteria?
Miscellaneous discharges including desalinization blowdown and lab sink drainage	<10 BPD (< 1.6 m^3 per day)	None	NA
Tanker ballast water	Maximum 629,000 bbl (100,000 m^3) total (at each tanker crude loading)	Perform in accordance with IMO requirements	No
BOP system testing water-soluble low-toxicity hydraulic fluid	30 bbl (4.8 m^3) every 2 weeks	None	NA
Grey water	250 BPD (40 m^3 per day)	None	NA
Black water (sewage)	85 BPD (13.6 m^3 per day)	Where chlorination (secondary method following UV sterilization) is performed, total residual chlorine as low as practical but not less than 1 ppm Thermotolerant coliforms not to exceed 100 CFU / 100 mL	Yes
Food preparation wastes	<40 BPD (<6.4 m^3 per day)	Macerated to <25 millimeters diameter	Yes
Firefighting foam monitor testing discharge	<6 bbl (<0.95 m^3) per year (at annual fire monitor testing event)	None	NA

BOP = blowout preventer; BPD = barrels per day; IMO = International Maritime Organization; CFU = Colony-forming Units; mL = milliliter; NA = not applicable

[a] Effluent characteristics and volumes/rates are based on the preliminary Project design information available at the time of the EIA.

[b] FPSO slop tank water includes deck drainage in addition to off specification oil from the process. While the expected volume of off-specification oil will be negligible, if it rains significantly, the expected discharge volume for this stream would increase (though the increase would be entirely rainwater).

[c] During production line commissioning and planned and unplanned shutdowns

Based on the estimated discharge rates in Table 6.4-8, cooling water, produced water, and brines from the sulfate removal, ultrafiltration, and wash water processing system (all associated with the production operations stage) are the operational discharges that are significant enough to require assessment, and thus these were the focus of modeling to assess the nature and extent of potential marine water quality impacts (considering indirect effects on marine life). Additionally, although the discharge of hydrotest water and commissioning fluids will occur over only a short time period during the SURF installation and commissioning stage, they were also included in the offshore discharge modeling as a conservative approach to assessing potential impacts. Potential impacts from the other effluent discharges listed above were considered to be negligible.

The constituents considered for each of these modeled discharges are listed in Table 6.4-9. The constituents are associated with potential indirect impacts on marine aquatic life, as indicated in the table.

Table 6.4-9: Summary of Modeled Discharges and Considered Constituents for Production Operations and SURF Hydrotesting

Modeled Discharge	Considered Constituents	Potential Direct Impacts on Water Quality (and Indirect Impacts on Marine Aquatic Life)
Cooling Water	• Temperature • Residual chlorine	Temperature increase and reduced DO concentrations (changes to metabolisms and avoidance impacts on marine species) Increased residual chlorine concentrations (toxicity impacts on marine species)
Produced Water	• Oil and grease • Temperature • Residual production-related and water treatment chemicals (e.g., scale and corrosion inhibitors)	Temperature increase and increased concentrations of oil and grease and production-related and water treatment chemicals (toxicity impacts on marine species)
Sulfate Removal, Ultrafiltration, and Wash Water Processing Brines	• Hypochlorite • Electrolyte • Biocide • Oxygen scavenger • Scale Inhibitor	Increased chemical concentrations (toxicity impacts on marine species)
Hydrotest Water	• Biocides • Oxygen scavenger • Corrosion inhibitor	Increased chemical concentrations (toxicity impacts on marine species)
Gas Injection Line Commissioning Fluid	• Hydrate inhibitor (e.g., methanol or monoethylene glycol)	Increased chemical concentrations (toxicity impacts on marine species)

The cooling water discharge is the return flow associated with a routine operational process used to cool selected machinery onboard the FPSO. The cooling water discharge will have an elevated temperature (relative to the ambient water temperature for the marine environment) and will contain a limited amount of hypochlorite (generated from seawater and added as an anti-biofouling agent). Aquatic species may be indirectly impacted by the elevated temperature, decreased DO, and residual chlorine in the discharge. Elevated temperatures and decreased DO may result in aquatic species avoiding regions close to the discharge. Residual chlorine may interact with naturally occurring organic matter, resulting in chlorinated byproducts with the potential to result in indirect toxicity impacts on aquatic species.

Discharge of produced water containing oil and grease and residual quantities of certain production-related and water treatment chemicals can result in localized increases in concentrations of chemical constituents in the marine environment. Discharge of sulfate removal, ultrafiltration, and wash water processing brines can also result in localized increases in concentrations of chemical constituents in the marine environment. Depending on the specific

constituent concentrations in these discharges, some aquatic species may experience indirect toxicity impacts from these constituents. Additionally, the produced water discharge will have an elevated temperature (relative to the ambient water temperature for the marine environment).

Hydrotest water discharges may contain biocides, oxygen scavengers, and corrosion inhibitors, which can result in localized increased concentrations of chemical constituents and associated potential for indirect toxicity impacts on aquatic species. The hydrotest discharge and hydrate inhibitor discharge will occur only during a limited time period during SURF installation and commissioning activities, unlike the discharge of cooling water, produced water, and sulfate removal and wash water processing brines discharge, all of which will occur continuously during production operations.

Water Quality Modeling

The USEPA-approved Cornell Mixing Zone Expert System (CORMIX)[22] dilution model was used to predict the nature and extent of discharge plumes from the various modeled discharges. CORMIX is a design tool routinely used by regulatory agencies to estimate mixing zones resulting from water discharges. Understanding the mixing characteristics of the various discharges and assessing impacts requires consideration of the properties of the discharged effluent (e.g., temperature), the properties of the receiving (ambient) water, and the method by which the discharge stream enters the ambient water (e.g., pipe, diffusers). Collectively, these factors control the near-field mixing and dilution of the discharge.

Discharge velocity, an important determinant of the mixing characteristics of a discharge, is directly related to the discharge pipe diameter. At a given discharge flow rate, smaller pipe diameters result in higher exit velocities, which facilitate increased mixing. However, engineering constraints may limit the degree to which the pipe diameter can be reduced. Similarly, the location of the discharge pipe (submerged or above water) can significantly influence the near-field mixing. An above-water-surface discharge accelerates under gravity to reach increased velocities before entering the sea, a desirable outcome that can be achieved if further reductions in pipe diameter are not practicable. As the detailed design for the Project has not been finalized, conservative assumptions were used for the modeled discharge pipe diameters. Pipe diameters that are smaller than those considered in the modeling will result in increased mixing (and faster dilution within a given distance from the discharge), relative to those predicted by modeling.

For the receiving environment, the ambient currents selected for modeling consisted of bounding cases (5th and 95th percentile for the range of current velocities identified) as well as a typical case (50th percentile for the range of current velocities identified). Ambient temperatures selected for modeling also consisted of bounding cases (1st and 99th percentiles) and a typical case (50th percentile).

The modeling of potential impacts from these discharges found that even under the most conservative bounding case for each discharge modeling scenario, the discharges were subject

[22] http://www.cormix.info/

to rapid mixing and, consequently, experienced substantial reductions in constituent concentrations within a small distance from the point of discharge.

Additional detail on the methodology for discharge modeling, as well as modeling results, are provided in Appendix C, Water Quality Modeling Report. These are summarized below.

Cooling water discharges are typically regulated based on consideration of native aquatic species. These standards are more stringent in coastal and inland waters due to the presence of sensitive aquatic receptors and the limited area available for mixing. In offshore waters, such standards are usually absent. For this modeling activity and assessment, an internationally recognized thermal guidance of 3°C (5.4ºF) maximum temperature change at 100 meters (328 feet) from the point of discharge was used. Hypochlorite, added to cooling water to avoid biofouling, is either regulated as an end-of-pipe concentration or at the end of a mixing zone. However, the residual chlorine from the hypochlorite only poses risk to aquatic species if they are exposed to elevated concentrations for extended periods of time (72 to 96 hours). Although not technically applicable to a cooling water discharge, the assessment utilized the International Maritime Organization's (IMO's) *2012 Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plant*s recommendation that when chlorine is used as a disinfectant, good international oilfield practice is to keep the disinfectant residual in the effluent below 0.5 mg/L (IMO 2012; World Bank 2015).

The end-of-pipe concentration of oil and grease in produced water has an international guideline (World Bank 2015) of a maximum monthly average of 29 mg/L and a daily maximum of 42 mg/L. The USEPA compliance guidance document for the Gulf of Mexico (Final NPDES[23] General Permit for New and Existing Sources and New Discharges in the Offshore Subcategory of the Oil and Gas Extraction Category for the Western Portion of the Outer Continental Shelf of the Gulf of Mexico [GMG290000]) requires treatment chemicals such as biocides, corrosion inhibitors, or other chemicals used to prevent corrosion or fouling of piping or equipment to be limited by the following constraints (USEPA 2017):

- The maximum concentration and any other conditions specified in the USEPA product registration labeling; or
- The maximum manufacturer's recommended concentration; or
- 500 mg/L.

Table 6.4-10 summarizes the results of the modeling of thermal discharges at 100 meters (328 feet) from the discharge point (considering the international guideline adopted for thermal discharges) for cooling water and produced water. At this time, the specific treatment chemicals that will be used in the processing brines, produced water, or hydrotest water have not been determined. However, to assess the degree of dilution that will result for these discharges, the percent reduction in constituent concentrations at the same 100-meter (328-foot) reference distance from the discharge is summarized in the table. Results are presented for the most

[23] National Pollutant Discharge Elimination System

conservative (i.e., least dilution) scenarios, considering the various combinations of ambient currents and temperatures.

Table 6.4-10: Summary of Modeling Results for Most Conservative Modeling Scenarios (Predicted Results at 100-Meter Reference Distance)

Discharge	Most Conservative Modeling Scenario Conditions	Modeled Parameters/ Constituents	Modeled Results at 100 Meters
Cooling Water (Thermal)	Minimum ambient temperature, maximum ambient current	Temperature rise	Ambient temperature rise <3 °C (5.4 °F)
Cooling Water (Hypochlorite)	Minimum ambient temperature, maximum ambient current	Residual chlorine	97.9% reduction (0.10 mg/L)
Produced Water	Minimum ambient current	• Temperature rise • Oil and grease [a] • Residual production chemicals	Ambient temperature rise <3 °C (5.4 °F) 98.2% reduction in oil and grease and other residual production chemicals
Sulfate Removal, Ultrafiltration and Wash Water Processing Brines	Maximum ambient current	• Hypochlorite • Electrolytes • Biocide • Oxygen scavenger • Scale inhibitor	98.1% reduction
Hydrotest Water	Minimum ambient current (6-inch pipe)	• Biocide • Oxygen scavenger • Corrosion inhibitor	98.9% reduction
Hydrate Control Fluid (Gas Injection Line Commissioning Fluid)	Maximum ambient current (2-inch pipe diameter)	Hydrate inhibitor (either methanol or ethylene glycol)	99.6% reduction in ethylene glycol or 99.9% reduction in methanol

[a] Discharges will adhere to a limit of 42 mg/L oil and grease (daily maximum) and 29 mg/L (monthly average) at the point of discharge (consistent with recognized international benchmarks).

Magnitude Ratings

Considering the results of the modeling discussed above, temperature rise and chemical constituent concentrations will dilute substantially within a short distance of the discharges (well within the PDA), and thus will be limited to a portion of the **Direct AOI**. The various operational discharges will occur continuously throughout the operational stage of the Project life cycle (at least 20 years). Based on this, the frequency designation is **Continuous** for the operational stage, with a duration of **Long-term** for all discharges. In terms of the intensity of the potential impacts on marine water quality from production operations and hydrotesting discharges, Table 6.4-11 summarizes the assigned intensity designations for the various discharge types

based on consideration of the modeling results and the definitions of the intensity ratings presented in Table 6.4-7.

Table 6.4-11: Intensity Ratings Summary for Modeled Production Operations and Hydrotesting Discharges

Discharge Type	Intensity Rating	Rationale for the Intensity Rating Assigned
Cooling Water	Low	Modeling indicates the temperature rise above ambient conditions will be no more than 3°C (5.4ºF) at the 100-meter (328-foot) reference distance from the discharge. At this same distance, chlorine concentrations are predicted to decrease by 97.9% to a concentration of 0.10 mg/L (which is 20% of the above-referenced IMO discharge standard). The IMO discharge standard of 0.5 mg/L is predicted to be achieved within 6.5 meters (21.3 feet) from the discharge.
Produced Water	Low	Modeling indicates the temperature rise above ambient conditions will be no more than 3°C (5.4ºF) at the 100-meter (328-foot) reference distance from the discharge. At this same distance, concentrations of oil and grease and residual production-related and water treatment chemicals are predicted to decrease by 98.2%.
Sulfate Removal, Ultrafiltration and Wash Water Processing Brines	Low	At the 100-meter (328-foot) reference distance, concentrations of hypochlorite, electrolyte, biocide, oxygen scavenger, and scale inhibitor are predicted to decrease by 98.1%.
Hydrotest Water	Low	At the 100-meter (328-foot) reference distance, concentrations of biocide, oxygen scavenger, and corrosion inhibitor are predicted to decrease by 98.9 to 99.6%, depending on pipe diameter. Additionally, each release event will be short-term in nature (approximately 60 minutes or less).
Hydrate Inhibitor (Gas Injection Line Commissioning Fluid)	Low	At the 100-meter (328-foot) reference distance, the concentration of hydrate control fluid (methanol or monoethylene glycol) is predicted to decrease by 99.6 to 99.9%, depending on the fluid selected. Additionally, the release event will be short-term in nature (a matter of hours).

Design specifications for the cooling water and produced water discharges were not finalized at the time of the EIA; modeling was conducted based on the preliminary design, with a single discharge point for each discharge, and discharge temperatures of 50°C and 55°C for cooling water and produced water, respectively. Modeling for these configurations/temperatures showed that the temperature rise above ambient conditions drops to less than 3°C (5.4ºF) at less than 10 meters from the discharge points. Based on final design, the discharge configurations could differ from what was modeled (e.g., the cooling water discharge could be configured through several smaller-flowrate discharges), and discharge temperatures could be higher than the temperatures modeled. Prior modeling for other EEPGL development projects has shown adherence to the “less than 3ºC temperature rise at 100 meters” standard for a range of discharge configurations and for higher temperatures. It is thus anticipated that the final designs for these discharges will demonstrate adherence to the thermal standard as well. This will be confirmed once the discharge designs are finalized.

Based on the limited area impacted, the magnitude of impacts on marine water quality from production operations and hydrotesting discharges is considered **Small** for all of the discharges assessed (see Table 6.4-12).

Table 6.4-12: Magnitude Ratings for Potential Impacts from Production, Operations, and Hydrotesting Discharges

Stage	Receptor—Impact	Discharge Type	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Installation, Commissioning, and Start-up Production Operations	Marine Water Quality	Cooling Water	Direct AOI	Low	Continuous	Long-term	Small
		Produced Water	Direct AOI	Low	Continuous	Long-term	Small
		Sulfate Removal, Ultrafiltration, and Wash Water Processing Brines	Direct AOI	Low	Continuous	Long-term	Small
		Hydrotest Water	Direct AOI	Low	Continuous	Long-term	Small
		Hydrate Inhibitor (Gas Injection Line Commissioning Fluid)	Direct AOI	Low	Continuous	Long-term	Small

Sensitivity of Resource—Changes to Water Quality and Temperature

The definitions used to designate sensitivity of receptors to increases in temperature and concentrations of pollutants are shown in Table 6.4-13. The direct impacts of these changes are to water quality. As this can have an indirect impact on marine biota, the sensitivity of these potential receptors has also been taken into account in assigning the level of sensitivity. Impacts of changes in temperature and concentrations of pollutants on marine biota are discussed in Section 7.8, Marine Fish, and Section 7.9, Marine Benthos.

Table 6.4-13: Definitions for Receptor Sensitivity Ratings for Potential Impacts from Production Operation and Hydrotest Discharges

Criterion	Definition
Sensitivity	Low: Species have sufficient mobility to avoid regions of elevated concentrations; high tolerance to exposure concentrations
	Medium: Species have limited mobility to avoid regions of elevated concentrations; moderate tolerance to exposure concentrations
	High: Species are confined to regions of elevated concentrations; low tolerance to exposure concentrations

On the basis of consideration of potential marine fauna that could be impacted in the PDA, the sensitivity of the marine environment to elevated constituent concentrations and increased temperature is considered **Low**.

Impact Significance—Changes to Water Quality and Temperature

Based on the magnitude of impact and resource sensitivity ratings, the significance of potential impacts on marine water quality from changes in water quality and temperature resulting from production operations and hydrotesting discharges is considered **Negligible**.

6.4.4. Management Measures—Marine Water Quality

Potential marine water quality impacts are addressed by a suite of embedded controls related to water quality management (see summary in Chapter 13, Recommendations). While the pre-mitigation impact significance ratings demonstrate that potential impacts can be addressed through the use of these embedded controls, the following mitigation measure is recommended to further address potential impacts from FPSO effluent discharges:

- Following start-up of production operations, implement a program to characterize effluent discharges from the FPSO and conduct an environmental risk assessment based on the characterization data. As appropriate based on the results of the environmental risk assessment, implement additional treatment options, if warranted and feasible.

Table 6.4-14 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 6.4-14: List of Embedded Controls and Monitoring Measures

Embedded Controls
When NADF is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9% wet weight base fluid retained on cuttings.
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.
For all vessel effluent discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage), comply with IMO and MARPOL 73/78 requirements.
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 mg/L on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored and the discharge meets the noted specification.
Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C (5.4ºF) at 100 meters (approximately 328 feet) from discharge point.
Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals.
Implement chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes; • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility;

• Risk evaluation of residual chemical releases into the environment.
For wastewater effluent released from the onboard sewage treatment plant, comply with aquatic discharge standards in accordance with MARPOL 73/78 regulations.
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter particle size or less) prior to discharge.
Confirm there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge.
Treat bilge water in accordance with MARPOL 73/78 to comply with an oil–in-water content of less than 15 ppm, as applicable. Perform oil-in-water content (automatic) monitoring of bilge water to verify compliance with 15 parts per million MARPOL 73/78 limit and record in Oil Record Book.
Mitigation Measures
Following start-up of production operations, implement a program to characterize effluent water discharges from the FPSO and conduct an environmental risk assessment based on the characterization data. As appropriate based on the results of the environmental risk assessment, implement additional treatment options, if warranted and feasible.
Monitoring Measures
Monitor residual chlorine concentration of sewage discharges from the FPSO monthly to stay below 0.5 mg/L in accordance with IMO regulations.
Perform daily visual inspections on the FPSO of discharge points to verify that there are no floating solids or discoloration of the surrounding waters.
Monitor daily during drilling to verify that end of well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9% wet weight base fluid retained on cuttings.
Monitor daily produced water discharge volume.
Measure oil and grease content of produced water (grab sample once per day).
Perform daily inspections to verify no visible sheen from discharge of cooling water.
Monitor discharge temperature of cooling water and produced water to avoid increases in ambient water temperature of more than 3°C (5.4ºF) at 100 meters (approximately 328 feet) from point of discharge.
Utilize load-monitoring system in the FPSO control room to support FPSO offloading.
Monitor pressure and temperature of subsea wells and manifolds by a control system on the FPSO to detect and prevent leaks.
Perform daily visual inspection of discharge points to verify absence of floating solids or discoloration of the surrounding waters.
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book.
Perform oil in water content (automatic) monitoring of bilge water to verify compliance with 15 ppm MARPOL 73/78 limit and record in Oil Record Book.
Record estimated volume of ballast water discharged and location (per ballasting operation).

Table 6.4-15 summarizes the assessment of potential pre-mitigation and residual Project impacts on marine water quality. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the marine water quality-specific methodology described in Sections 6.4.3.2 and 6.4.3.3.

Table 6.4-15: Summary of Potential Pre-Mitigation and Residual Impacts—Marine Water Quality

Stage	Resource - Impact	Magnitude Rating	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Well Drilling	Marine water quality (marine fauna)—increased TSS concentrations and potential health impacts	Medium	Low	Minor	None	Minor
SURF/FPSO Installation, Commissioning, and Start-up Production Operations	Marine water quality (marine fauna)—changes to water quality and temperature	Small	Low	Negligible	None	Negligible

7. ASSESSMENT AND MITIGATION OF POTENTIAL IMPACTS FROM PLANNED ACTIVITIES—BIOLOGICAL RESOURCES

The biological resources existing conditions discussion presented herein is based on a combination of primary data generated from EEPGL-commissioned studies and secondary data from peer-reviewed scientific literature, government publications, and non-governmental scientific organizations. The EEPGL-commissioned studies used in the assessment of baseline conditions were drawn from a combination of studies conducted in accordance with the conditions of environmental permitting for previous projects and additional studies that were not required by permit conditions.

The following studies were conducted between 2017 and 2018 to satisfy conditions of the Environmental Permit issued for the Liza Phase 1 Development Project, and were used to support the Yellowtail EIA:

- Final Environmental Baseline Assessment of Sediment Quality Along the Continental Shelf Guyana—Phase 2
- Remotely Operated Vehicle Imagery Analysis
- Protected Species Observer Surveys (Year 1)
- 2018 Turtle Tagging and Telemetry Program (Year 1)
- Marine Bird Study (Year 1)
- Enhanced Coastal Sensitivity Mapping—Biodiversity and Ecosystem Services (Regions 1-4)
- Nearshore and Offshore Fisheries Study Summary Report 2017-2018 (Year 1)

In addition, EEPGL elected to extend most of the Permit condition-driven studies beyond the timeframes required by the Liza Phase 1 Environmental Permit. Further, several new studies have been completed by EEPGL or its contractors since the Permit condition-driven studies listed above were completed. The data from the original Permit condition-driven studies and from the extended portions of these studies have been considered—where relevant—in development project EIAs completed since the Liza Phase 1 Development Project EIA, including the Yellowtail Development Project EIA. Baseline information from several studies (including some of those that originated as a permit condition as listed above but have since been expanded beyond the timeframes required by the Liza Phase 1 Environmental Permit, and several others) was utilized for EIA purposes for the first time in the Yellowtail EIA. Although the data in these study reports were not collected for the exclusive purpose of supporting the Yellowtail EIA, the reports for these studies were not used in any prior EEPGL EIA and are being provided to the EPA and the public for the first time in the Yellowtail EIA. These study reports include the following, each of which are included as an appendix to the Yellowtail EIA (Volume II):

- Marine Bird Study Report: Marine Bird Survey 2017–2020 (Volume II, Appendix K)
- Coastal Bird Survey Report: Coastal Bird Study 2017–2020 (Volume II, Appendix L)

- Final Analysis Report—2018-2020 Shell Beach Turtle Tracking Project (Volume II, Appendix Q)
- Nearshore and Offshore Fisheries Study Summary (Volume II, Appendix M)
- Environmental Baseline Survey and Habitat Assessment: Continental Slope AUV Survey, Hammerhead Development, Offshore Guyana (Volume II, Appendix I)
- Environmental Baseline Survey ExxonMobil Hammerhead Development Offshore Guyana (Volume II, Appendix I)
- ExxonMobil Multi AUV Geophysical Survey Protected Species Observer Summary Report (Volume II, Appendix N)
- Enhanced Coastal Sensitivity Mapping—Ecosystem Services Final Reports (Volume II, Appendix S)
- Participatory Fishing Study Final Report January 2019–March 2020 (1Q data were reported in the Payara EIA) (Volume II, Appendix D).

Specifically, the information presented for protected areas and special status species was gathered from government publications and the International Union for the Conservation of Nature (IUCN), a non-governmental scientific organization, whereas the information presented for coastal habitats and specific biological taxa groups such as seabirds, coastal birds, marine fish, marine and riverine mammals, marine turtles, and marine benthos was generated from EEPGL-commissioned studies and supplemented by scientific literature and government data.

7.1. PROTECTED AREAS AND SPECIAL STATUS SPECIES

7.1.1. Administrative Framework—Protected Areas and Special Status Species

Table 7.1-1 summarizes the legislation, policies, or treaty commitments that are specifically relevant to the assessment of potential impacts on protected areas and special status species.

Table 7.1-1: Legislation, Policies, or Treaty Commitments—Protected Areas and Special Status Species

Title	Objective	Relevance to the Project
Legislation		
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013; the Wild Birds Protection Act, 1987; and the Species Protection Regulations, 1999)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a framework to address the national goals for wildlife protection, conservation, and management. The Act also provides recommendations on measures for the protection of threatened ecosystems and habitats, and advises on measures for

Title	Objective	Relevance to the Project
		conservation of biological diversity.
Protected Areas Act, 2011 (also discussed in Chapter 3, Administrative Framework)	Provides for protection and conservation of Guyana's natural heritage and natural capital through a national network of protected areas; the maintenance of ecosystem services of national and global importance, including of climate regulation; and the fulfilment of Guyana's international environmental responsibilities. This act also allowed for the creation of the Protected Areas Commission to oversee the management of this network. It highlights the importance of maintaining ecosystem services of national and global importance and public participation in the conservation of protected areas. It establishes a protected-areas trust fund to ensure adequate financial support for maintenance of the network. Other functions of this act include promoting national pride in and encouraging stewardship of Guyana's natural heritage; recognizing the conservation efforts and achievements of Amerindian villages and Amerindian communities; and promoting the recovery and rehabilitation of vulnerable, threatened, and endangered species.	Shell Beach, which is a coastal area subject to potential impact from a Project unplanned event (i.e., oil spill), was identified as one of the five priority areas for establishment of protected areas in Guyana and was designated a protected area with the passage of the Protected Areas Act in 2011.
International Agreements Signed / Acceded by Guyana		
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (Guyana acceded and ratified in 2010)	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection for the marine environment, especially from possible pollution.
Protocol on Specially Protected Areas and Wildlife (Guyana acceded and ratified in 2010)	Protocol supplementing and supporting the Cartagena Convention. Requires signatories to adopt an ecosystem approach to conservation. Provides mechanism for compliance with the Convention on Biological Diversity.	Elaborates on the wildlife goals established in the Cartagena Convention and Convention on Biological Diversity.
Convention on Biological Diversity (Guyana signed in 1992 and ratified in 1994)	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Encourages Project design and execution to protect and conserve biological diversity.

7.1.2. Existing Conditions—Protected Areas and Special Status Species

7.1.2.1. Protected Areas

Formerly, the EPA was Guyana's focal point for the Convention on Biological Diversity, and the agency coordinated the National Protected Areas System (Guyana Chronicle 2014), which included five protected areas. In 2011, Guyana enacted the Protected Areas Act, which established a Protected Areas Commission to oversee and manage protected areas. This legislation established a list of prohibited activities, including unlawfully entering or remaining within a protected area; disturbing or destroying the vegetation (common or endangered); removing or exterminating wildlife species (common or endangered); damaging archaeological finds or sites; and mining. Guyana's National Biodiversity Strategy and Action Plan (EPA and MoNRE 2015) describes the overall importance of biodiversity's role within the country.

> "Guyana's biodiversity provides an important basis for climate regulation, poverty reduction, provisioning of fresh water and hydropower, economic growth and development in areas such as agriculture, forestry and fisheries, payment for forest climate services, community based economies, particularly in hinterland communities and biodiversity-related education, scientific research and recreation. Loss of biodiversity and any disruption in the provision of ecosystem services would impact negatively on the economy and more particularly on the quality of life in the hinterland and indigenous communities."

The 2011 legislation also established Shell Beach and the Kanuku Mountains as Guyana's newest nationally protected areas. This increased the total number of protected areas in Guyana to five and increased the total land area protected to approximately 1.79 million hectares (4.42 million acres), or about 8.5 percent of Guyana's land area, as summarized in Table 7.1-2 (Protected Areas Trust 2021). Figure 7.1-1 illustrates the locations of Guyana's protected areas. There are currently no designated marine protected areas in Guyana.

Table 7.1-2: Protected Areas in Guyana

Protected Area	Area (hectares)
Kaieteur National Park	62,700
Iwokrama Forest	371,000
Kanashen Amerindian	625,000
Kanuku Mountains	611,000
Shell Beach Protected Area	123,000

Source: Protected Areas Trust 2021

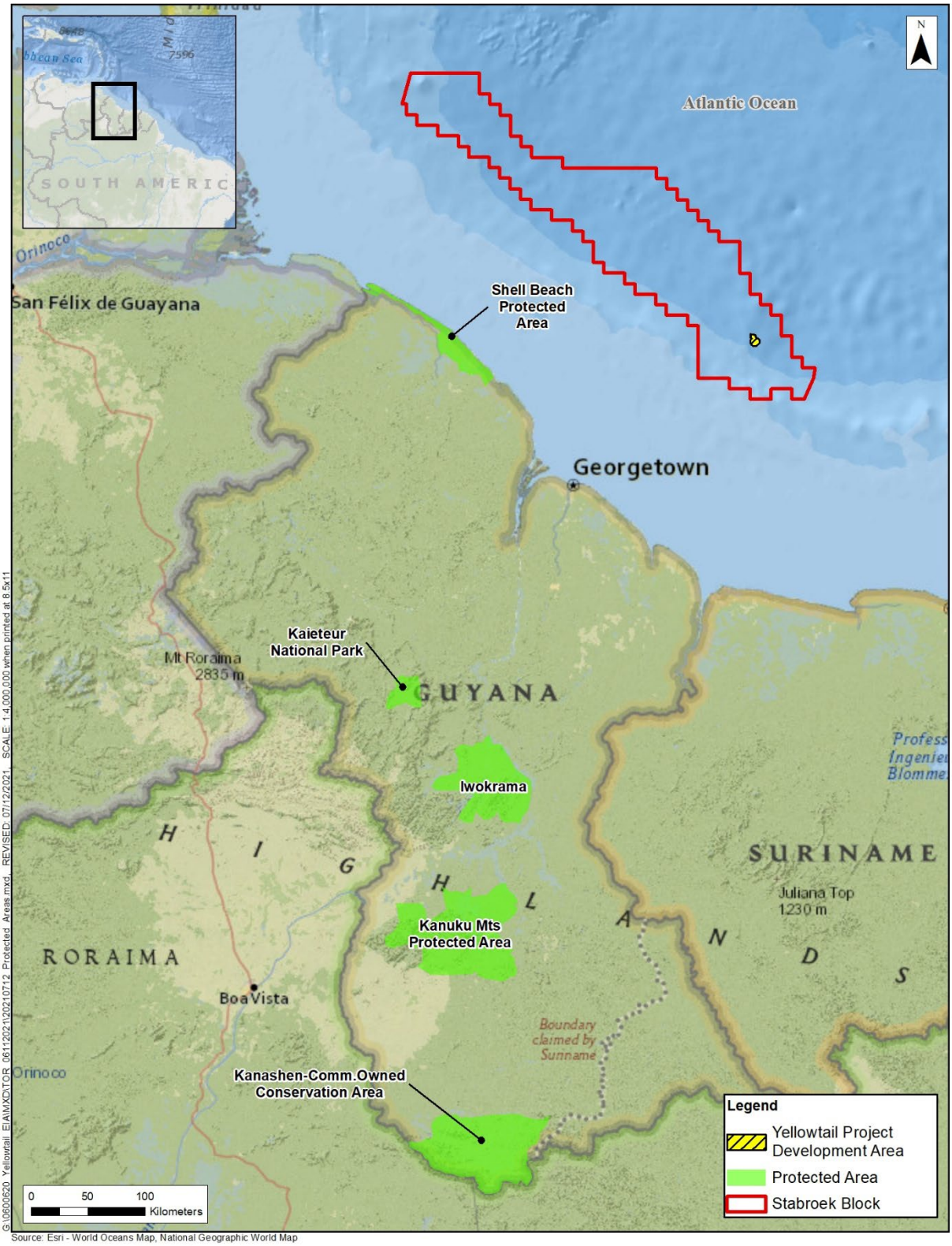


Figure 7.1-1: Protected Areas of Guyana

Of the five protected areas, Shell Beach Protected Area (SBPA) is the only one located on Guyana's coast, and is most pertinent to the assessment of potential impacts from the Project. SBPA includes Guyana's coastline but does not extend into the Atlantic Ocean; however, the ecology of the coastal zone and Shell Beach are inextricably connected to the coastal marine ecosystem. The SBPA is managed by the Protected Areas Commission; the management framework for the protected area is described in the Shell Beach Protected Area Management Plan 2015-2019 (PAC 2014).

Figure 7.1-2 provides a detailed map of SBPA, the beaches it incorporates, and the surrounding area. It is located in northern Guyana and extends for almost 140 kilometers (approximately 87 miles), and is bordered by the Waini, Baramani, and Moruka rivers and the Atlantic Ocean. The Project Development Area (PDA) is located 227 kilometers (141 miles) northeast of the southernmost (closest) point of SBPA.

Shell Beach, which derived its name from the fact that its entire stretch of coastline is comprised mainly of pulverized crustacean shells (EPA et al. 2004), is a dynamic area. Its landscape constantly changes due to the competing impacts of erosion and accretion along the shoreline. The area is 70 percent forested; the rest is made up of mostly swamp (less than 30 percent) and sandy beaches (less than 1 percent) (Kandaswamy 2014). Shell Beach supports numerous plant species, including coconut, papaya, and palm trees (GMTCS 2011; Bovell 2011).

The vegetative community has changed little in recent history apart from limited clearing to accommodate a few dispersed encampments and farmsteads. The rivers bordering the SBPA discharge nutrients through the protected area's mudflats and mangroves. These high nutrient levels contribute to the productivity of the marine ecosystem. Fish, prawns, and crabs from the nearshore marine area use the mangrove covered coastlines as nursery habitat (Protected Areas Trust 2021).

Shell Beach is best known as a marine turtle nesting site. The composition of the substrate at Shell Beach, its geographical location, and the low anthropogenic activity makes it an ideal nesting site for marine turtles (Convention on Biological Diversity 2015). Most nesting beaches in Guyana are used by only one or two species of marine turtles, but four species (leatherback turtle [*Dermochelys coriacea*], hawksbill turtle [*Eretmochelys imbricata*], olive ridley turtle [*Lepidochelys olivacea*], and green turtle [*Chelonia mydas*]) nest at Shell Beach (Pritchard 2001). In addition to marine turtles, there are also at least four other species of turtles present within the SBPA, including yellow-footed tortoise (*Geochelone denticulata*), scorpion mud turtle (*Kinosternon scorpioides*), giant river turtle (*Podocnemis expansa*), and mata mata (*Chelus fimbriata*).

The SBPA also supports rich bird, herpetofauna (reptiles and amphibians), and mammal communities. The 2004 Rapid Biodiversity Assessment (EPA et al. 2004) documented 170 species of birds, 20 species of mammals, and 31 species of herpetofauna. The 170 species of birds represent one of the richest populations in Guyana and include well-known species such as Scarlet Ibis (*Eudocimus ruber*), Roseate Spoonbill (*Platalea ajaja*), and Caribbean Flamingo (*Phoenicopterus ruber*), Orange-winged Amazon Parrot (*Amazona amazonica),* and several species of macaws.

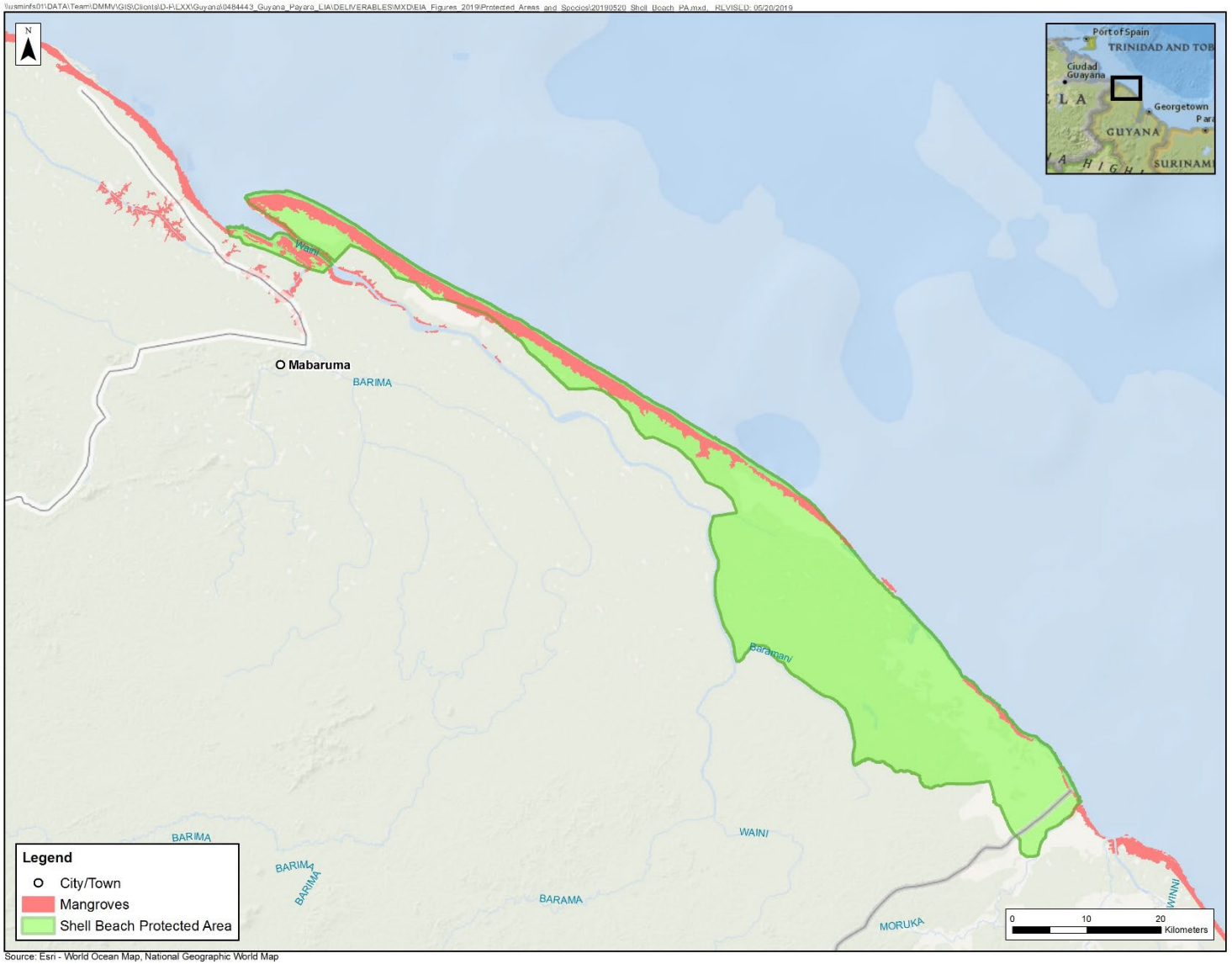


Figure 7.1-2: Shell Beach Protected Area

Sixteen herpetofauna species (other than turtles) are known to inhabit the Shell Beach area. These include Ameiva lizard (*Ameiva ameiva*), rainbow whiptail lizard (*Cnemidorphous lemniscatus*), water labaria (*Helicops angulatus)*, cane toad (*Rhinella marina*), paradoxical frog (*Pseudis paradoxa*), and numerous tree frogs (*Hyla* spp.) (EPA et al. 2004).

Resources within protected areas are a key factor in supporting local communities (see Section 8.9, Ecosystem Services, for additional information). Areas within and near Shell Beach have been inhabited for 10,000 years by Amerindian groups from the Warao, Carib, and Arawak tribes (Charles et al. 2004). Most of the current indigenous residents of the Shell Beach area are concentrated in a community known as Almond Beach, near the northern end of the SBPA. Other communities included within the boundary of the SBPA, as delineated in 2011, include Father's Beach and Assakata. The remainder of the SBPA is sparsely populated, if at all.

Indigenous communities have historically used the Shell Beach area for subsistence fishing, crabbing, trapping, farming, logging, and palm harvesting. The important crab species that are used by the locals include blue sheriga (*Callinectes bocourti*), sheriga (*Portunas spinimamus*), bunderi (*Cardiosoma guanhumi*), and buck-crab (*Ucides cordatus*) (EPA et al. 2004). They have also historically engaged in marine turtle trapping and egg harvesting. While these activities have declined in recent years as emphasis on conservation and sustainability has increased, illegal catching of turtles may still occur (Charles et al. 2004).

Increasing human activity in proximity to Shell Beach has led to increasing exploitation of natural resources and has the potential to lead to additional ecological harm. In 1997, a fire caused by human activity extensively damaged an area of mangroves (Pritchard 2001). Throughout the past few decades, there have also been various industrial proposals for Shell Beach. These include proposals to extract shell material from the beaches as feedstock for fertilizer production and to develop a luxury tourist outpost (Charles et al. 2004). Amerindian communities in the area have also expressed interest in developing ecotourism in the area (Charles et al. 2004).

7.1.2.2. Special Status Species

The IUCN Red List is the definitive authority on global species conservation status. In addition to the global IUCN Red List, many countries have a National Red List that assesses species status at a national or smaller scale. Guyana does not have a National Red List (NRL 2018), so the IUCN Red List is used herein. For the purposes of this assessment, special status species are defined as those that are listed as: (1) Near Threatened (NT), Vulnerable (VU), Endangered (EN), or Critically Endangered (CR) on the IUCN Red List Version 2021.1 (IUCN 2021). Table 7.1-3 summarizes the IUCN Red List categories. Species categorized as CR, EN, and VU are collectively considered to be internationally "threatened," while NT species are considered to be close to qualifying as "threatened." Conversely, Least Concern (LC) species are considered internationally widespread and abundant. Species listed as Data Deficient (DD) are poorly understood, so their conservation status and extinction risk are unknown.

Table 7.1-3: Definitions of IUCN Red List Categories of Extinction Risk

IUCN Red List Status	Definition
Extinct (EX)	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), and throughout its historical range have failed to record an individual.
Critically Endangered (CR)	A taxon is Critically Endangered when the best available evidence (severe population decline, very small population, very small geographic area occupied, or a probability of extinction in the next 10 years of >50%) indicates that it is facing an extremely high risk of extinction in the wild.
Endangered (EN)	A taxon is Endangered when the best available evidence (large population decline, small population, small geographic area occupied, or a probability of extinction in the next 20 years of >20%) indicates that it is facing a very high risk of extinction in the wild.
Vulnerable (VU)	A taxon is Vulnerable when the best available evidence (substantial population decline, small population, fairly small geographic area occupied, or a probability of extinction in the next 100 years is >10%) indicates that it is considered to be facing a high risk of extinction in the wild.
Near Threatened (NT)	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered, or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.
Least Concern (LC)	A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable, or Near Threatened. Taxa that are widespread and abundant are included in this category.
Data Deficient (DD)	A taxon is Data Deficient when there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status.

Source: IUCN 2012

There are 296 species known to occur in the coastal or marine habitats in Guyana that are on the IUCN Red List. Eighty-four of these coastal or marine species have an elevated conservation status (i.e., are ranked NT, VU, EN, or CR) and are referred to in this section as “special status” species. An additional 13 species known to occur in the coastal or marine habitats in Guyana are listed by IUCN as DD (Appendix J, IUCN-Listed Coastal and Marine Species Known from Guyana with Red List Status Classified as Data Deficient).

The 84 species with an elevated conservation status include 62 fish, 11 birds, 4 marine turtles, 1 terrestrial turtle, and 6 mammals (2 marine mammal and 4 coastal/riverine mammal species). Table 7.1-4 lists these species, their current IUCN Red List status, their primary habitat association, and their potential to be impacted by planned Project activities. Species with an offshore distribution are generally considered to be susceptible to one or more Project-related impacts; the impact pathways relevant to each species are discussed in detail in Sections 7.4 through 7.8. Most species with exclusively coastal distributions could only be impacted by an unplanned event (i.e., oil spill), as described in Section 9.5, Unplanned Events—Protected Areas and Special Status Species; however, coastal species that are known to be susceptible to

impacts from vessel traffic (e.g., vessel strikes or acoustic impacts) are identified in Table 7.1-4 as having the potential to be impacted by planned Project activities.

The majority of special status species listed in Table 7.1-4 and Appendix J are fish, including highly migratory species such as tunas and sharks, bentho-pelagic species including certain groupers, and demersal species including species of skates and rays. As noted in Section 8.1.2, Existing Conditions—Socioeconomic Conditions, many of these fish species are also targeted by the Guyanese commercial fishing industry. According to the IUCN's classification scheme, these species currently face a credible threat of extinction. Table 7.1-4 indicates whether each of the 84 special status species has been detected during the following EEPGL-commissioned biological survey and monitoring activities conducted over the past several years:

- Marine and coastal bird surveys of the area between Georgetown and the Stabroek Block and within the Stabroek Block (eight sampling events): October 2017 (ERM 2018a); April 2018 (ERM 2018b); and October 2018, January 2019, April 2019, June 2019, September 2019, and February 2020 (Appendix K, Marine Bird Survey Report: Marine Bird Survey 2017–2020, and Appendix L, Coastal Bird Survey Report: Coastal Bird Study 2017–2020).
- Marine and coastal fish surveys (five sampling events): October 2017 and April 2018 (ERM 2018c), and November-December 2018, January 2019, and April/May 2019. See Appendix M, Nearshore and Offshore Fisheries Study Summary, for the results of the November/December 2018, January 2019, and April/May 2019 sampling events).
- Protected species observer monitoring (paired observer and passive acoustic monitoring) conducted during EEPGL seismic programs from 2015 through 2021. See Appendix N, ExxonMobil Multi AUV Geophysical Survey Protected Species Observer Summary Report, for the most recent protected species observations made in the Stabroek Block (from May 2020).
- Harbor mammal surveys conducted between the mouth of the Demerara River and the Demerara Harbour Bridge (two sampling events): April 2019 and May 2019 (see Section 7.6, Riverine Mammals).
- Marine benthos surveys (six sampling events): 2014 (Maxon and TDI Brooks 2014), 2016 (Fugro 2016), 2017 (ESL 2018), and 2018 (Fugro 2019); and 2019 and 2020 (Appendix I, Recent Environmental Baseline Survey Reports).

Figures 7.1-3, 7.1-4, and 7.1-5 are photographs of some of the IUCN Red List species observed during EEPGL-commissioned surveys.

Table 7.1-4: IUCN-Listed Coastal and Marine Species Known to Occur in Guyana with Red List Status of NT or Higher

Scientific Name	Common Name	IUCN Status	Primary Habitat in Guyana	Detected in EEPGL-Commissioned Studies	Potential to be Affected by Planned Project Activities
Birds					
Agamia agami	Agami Heron	VU	Coastal lowland forest and marsh		
Buteogallus aequinoctialis	Rufous Crab Hawk	NT	Coastal mangrove	X	
Calidris canutus	Red Knot	NT	Coastal mudflat and beach; marine during migration	X	X
Calidris pusilla	Semipalmated Sandpiper	NT	Coastal mudflat and beach; marine during migration	X	X
Conirostrum bicolor	Bicolored Conebill	NT	Coastal mangrove	X	
Harpia harpyja	Harpy Eagle	NT	Coastal mangrove	X	
Oceanodroma leucorhoa	Leach's Storm-Petrel	VU	Marine	X	X
Patagioenas subvinacea	Ruddy Pigeon	VU	Coastal and inland forest	X	
Picumnus spilogaster	White-bellied Piculet	VU	Coastal mangrove	X	
Pterodroma hasitata	Black-capped Petrel	EN	Marine	X	X
Ramphastos tucanus	Red-billed Toucan	VU	Coastal and riverine forest	X	
Mammals					
Lontra longicaudis	Neotropical otter	NT	Coastal and riverine forests, swamps, and rocky shorelines		
Physeter macrocephalus	Sperm whale	VU	Marine	X	X
Pseudorca crassidens	False killer whale	NT	Marine and coastal		X
Pteronura brasiliensis	Giant otter	EN	Rivers and swamps (inland)		
Sotalia guianensis	Guiana dolphin	NT	Coastal and riverine	X	X
Trichechus manatus	American manatee	VU	Coastal and riverine	X	X

Scientific Name	Common Name	IUCN Status	Primary Habitat in Guyana	Detected in EEPGL-Commissioned Studies	Potential to be Affected by Planned Project Activities
Marine and Terrestrial Turtles					
Chelonia mydas	Green turtle	EN	Marine and coastal	X	X
Dermochelys coriacea	Leatherback turtle	VU	Marine and coastal	X	X
Eretmochelys imbricata	Hawksbill turtle	CR	Marine and coastal	X	X
Geochelone denticulata	Yellow-footed tortoise	VU	Riverine and interior forest	X	
Lepidochelys olivacea	Olive ridley turtle	VU	Marine and coastal	X	X
Fishes					
Aetobatus narinari	Spotted eagle ray	EN	Offshore and coastal pelagic		X
Albula vulpes	Bonefish	NT	Coastal demersal	X	
Alopias vulpinus	Common thresher shark	VU	Offshore and coastal pelagic		X
Balistes capriscus	Grey triggerfish	VU	Coastal demersal	X	
Balistes vetula	Queen triggerfish	NT	Coastal demersal		
Carcharhinus acronotus	Blacknose shark	EN	Coastal pelagic		
Carcharhinus brevipinna	Spinner shark	VU	Coastal pelagic	X	
Carcharhinus falciformis	Silky shark	VU	Offshore pelagic		X
Carcharhinus leucas	Bull shark	NT	Coastal pelagic		
Carcharhinus limbatus	Blacktip shark	NT	Coastal pelagic		
Carcharhinus longimanus	Oceanic whitetip shark	CR	Offshore and coastal pelagic		X
Carcharhinus obscurus	Dusky shark	EN	Offshore and coastal pelagic		X
Carcharhinus perezi	Caribbean reef shark	EN	Offshore and coastal pelagic		X
Carcharhinus porosus	Smalltail shark	CR	Coastal demersal		
Carcharhinus signatus	Night shark	EN	Offshore pelagic		X
Diplobatis picta	Variegated electric ray	VU	Offshore and coastal demersal		X

Scientific Name	Common Name	IUCN Status	Primary Habitat in Guyana	Detected in EEPGL-Commissioned Studies	Potential to be Affected by Planned Project Activities
Epinephelus itajara	Atlantic goliath grouper	VU	Coastal demersal		
Epinephelus morio	Red grouper	VU	Coastal demersal	X	
Epinephelus striatus	Nassau grouper	CR	Coastal demersal		
Fontitrygon geijskesi	Sharpsnout stingray	CR	Offshore and coastal demersal	X	X
Galeocerdo cuvier	Tiger shark	NT	Offshore and coastal pelagic	X	X
Ginglymostoma cirratum	Atlantic nurse shark	VU	Coastal demersal		
Gymnura altavela	Spiny butterfly ray	VU	Coastal demersal		
Gymnura micrura	Smooth butterfly ray	NT	Coastal demersal	X	
Himantura schmardae	Chupare stingray	EN	Coastal demersal		
Hypanus americanus	Southern stingray	NT	Coastal demersal		
Hypanus guttatus	Longnose stingray	NT	Coastal demersal	X	
Hyporthodus flavolimbatus	Poey's grouper	VU	Coastal demersal		
Hyporthodus niveatus	Snowy grouper	VU	Coastal demersal		
Isogomphodon oxyrhynchus	Daggernose shark	CR	Coastal pelagic		
Isurus oxyrinchus	Shortfin mako	EN	Coastal pelagic		
Kajikia albida	White marlin	VU	Offshore pelagic		X
Lachnolaimus maximus	Hogfish	VU	Coastal demersal		
Lopholatilus chamaeleonticeps	Golden tilefish	EN	Offshore and coastal demersal		X
Lutjanus analis	Mutton snapper	NT	Coastal demersal	X	
Lutjanus cyanopterus	Cubera snapper	VU	Coastal demersal		
Lutjanus synagris	Lane snapper	NT	Coastal demersal	X	
Makaira nigricans [a]	Blue marlin	VU	Offshore pelagic	X	X
Mobula birostris	Giant manta ray	EN	Offshore and coastal pelagic		X

Scientific Name	Common Name	IUCN Status	Primary Habitat in Guyana	Detected in EEPGL-Commissioned Studies	Potential to be Affected by Planned Project Activities
Megalops atlanticus	Tarpon	VU	Coastal pelagic		
Mola mola	Ocean sunfish	VU	Offshore pelagic	X	X
Mycteroperca bonaci	Black grouper	NT	Coastal demersal		
Mycteroperca venenosa	Yellowfin grouper	NT	Coastal demersal		
Myliobatis freminvillii	Bullnose ray	VU	Coastal demersal		
Myliobatis goodei	Southern eagle ray	VU	Coastal demersal		
Negaprion brevirostris	Lemon shark	VU	Coastal pelagic	X	
Prionace glauca	Blue shark	NT	Offshore and coastal pelagic		X
Pristis pristis	Largetooth sawfish	CR	Coastal demersal		
Pseudobatos percellens	Southern guitarfish	EN	Coastal demersal	X	
Raja cervigoni	Venezuela skate	NT	Coastal demersal		
Rhincodon typus	Whale shark	EN	Offshore and coastal pelagic		X
Rhinoptera bonasus	Cownose ray	VU	Offshore and coastal demersal	X	X
Rhizoprionodon lalandii	Brazillian sharpnose shark	VU	Coastal demersal		
Sciades parkeri	Gillbacker sea catfish	VU	Coastal demersal	X	
Sphyrna lewini	Scalloped hammerhead shark	CR	Offshore and coastal pelagic		X
Sphyrna media	Scoophead shark	CR	Coastal demersal		
Sphyrna mokarran	Squat-headed hammerhead shark	CR	Offshore and coastal pelagic		X
Sphyrna tudes	Smalleye hammerhead shark	CR	Coastal pelagic		
Thunnus alalunga	Albacore tuna	NT	Offshore pelagic		X
Thunnus albacares	Yellowfin tuna	NT	Offshore pelagic	X	X

Scientific Name	Common Name	IUCN Status	Primary Habitat in Guyana	Detected in EEPGL-Commissioned Studies	Potential to be Affected by Planned Project Activities
Thunnus obesus	Bigeye tuna	VU	Offshore pelagic		X
Thunnus thynnus	Atlantic bluefin tuna	EN	Offshore pelagic		X

Source: IUCN 2021

[a] Blue marlin is not listed by the IUCN as occurring in Guyanese waters; however, blue marlin have been reported in Guyanese waters from EEGPL-commissioned vessels operating offshore Guyana.

Photo credit: Waldyke Prince

Figure 7.1-3: Bicolored Conebill (*Conirostrum bicolor*), IUCN Red List Near Threatened, at the Maida Seaside, January 2019

Photo credit: Waldyke Prince

Figure 7.1-4: White-bellied Piculet (*Picumnus spilogaster*), IUCN Red List Vulnerable, at Alness Seaside in Region 6, April 2019

Collected during January 2019 Fish Survey

Figure 7.1-5: Gillbacker Sea Catfish (*Sciades parkeri*), IUCN Red List Vulnerable

7.1.3. Impact Assessment—Protected Areas and Special Status Species

This section describes the assessment of potential impacts on protected areas and special status species.

7.1.3.1. Protected Areas

The planned Project activities, the bulk of which will occur approximately 203 kilometers (126 miles) northeast of the coastline of Georgetown, will not impact SBPA, which is Guyana's only designated protected area within the Project Area of Influence (AOI). The Project's only potential impacts on SBPA would be as a result of an unplanned event (i.e., an oil spill), which is discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

7.1.3.2. Special Status Species

For the purposes of this assessment, special status species are defined as those listed on the IUCN Red List as NT, VU, EN, or CR on the IUCN Red List Version 2021 (IUCN 2021) that are known or expected to occur in the Project AOI (see Section 7.1.2, Existing Conditions—Protected Areas and Special Status Species).

Relevant Project Activities and Potential Impacts—Special Status Species

Of the 84 special status species known or expected to occur in the Direct AOI, 48 will not be impacted by planned Project activities (Section 7.3.3, Impact Assessment—Coastal Wildlife). They would only potentially be affected by an unplanned event, the impacts of which are discussed in Sections 9.7, Coastal Wildlife, and Section 9.10, Riverine Mammals. Table 7.1-5 presents the distribution of the 36 remaining (non-coastal/inland) special status species, according to taxonomic group and IUCN Red List status, that could experience potential impacts from planned Project activities.

Table 7.1-5: Number of Special Status Species Potentially Affected by Planned Project Activities, Categorized by Taxonomic Group and IUCN Red List Status

Taxonomic Group	Number of Non-Coastal/Inland Special Status Species Known or Expected to Occur within the Direct AOI (IUCN Red List Status)
Marine turtles	4 (1 CR, 1 EN, 2 VU)
Riverine mammals	2 (1 NT, 1 VU)
Marine mammals	2 (1 NT, 1 VU)
Marine fish	24 (4 CR, 8 EN, 8 VU, 4 NT)
Seabirds [a] and other migratory birds that occur offshore Guyana in the Stabroek Block	4 (1 EN, 2 NT, 1 VU)

[a] For the purposes of this special status species assessment, the term “special status seabirds” includes two true seabird species (Black-capped Petrel [*Pterodroma hasitata*] and Leach’s Storm-Petrel [*Oceanodroma leucorhoa*]) and two migratory shorebird species that have been documented offshore Guyana in the Stabroek Block: Red Knot (*Calidris canutus*) and Semipalmated Sandpiper (*Calidris pusilla*).

Potential impacts from planned Project activities on special status species are the same as those described in the resource-specific impact sections of this EIA (Section 7.7.3, Impact Assessment—Marine Turtles; Section 7.5.3, Impact Assessment—Marine Mammals; Section 7.6.3, Impact Assessment—Riverine Mammals; Section 7.8.3, Impact Assessment—Marine Fish; and Section 7.4.3, Impact Assessment—Seabirds). As discussed in more detail in these resource-specific impact assessment sections, planned Project activities could result in a number of potential impacts on these resources, including: localized changes in the distribution of marine species as a result of altered water quality; acoustic disturbance impacts from Project-induced underwater sound; localized changes in distribution and habitat usage due to disturbance from sound, lighting, vessel traffic, human activity, or the presence of Project infrastructure; entrainment in water intakes; and potential attraction to lighting from the Floating Production, Storage, and Offloading (FPSO) vessel and flare pilots, drill ships, and major installation vessels.

Potential impacts on these groups of resources from unplanned events, including oil spills, discharges of untreated wastewater from the FPSO, contact with the FPSO flare or heat plume, and vessel and helicopter collisions with animals, are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

Magnitude of Impacts—Special Status Species

The impact magnitude rating describes the degree of change that the impact is likely to impart on the resource, without regard to resource sensitivity (see Section 4.8, Assessment of Impacts and Identification of Mitigation Measures). Impact magnitude is the same for special status and non-special status species because the rating describes the impact itself and the change it is likely to cause to the resource.

With the exception of the Black-capped Petrel (*Pterodroma hasitata*), the special status seabirds will have the same exposure to potential impacts as non-special status seabirds because their habitat use, behavior patterns, and biology are similar; accordingly, the magnitude ratings for special status species seabirds were not changed from those used for non-special status seabirds (Section 7.4). All of these species occur seasonally offshore Guyana and the broader Caribbean region, primarily during the non-breeding and migratory periods. For Black-capped Petrel (which is the only seabird listed as Endangered), the magnitude of potential impacts from attraction to offshore Project facilities and light and sound disturbance from offshore Project activities was considered **Negligible** due to the rarity of this species in the PDA and the very low likelihood that this species would be exposed to these types of potential impacts from the Project. As described in Section 7.4.3.2, Magnitude of Impacts—Seabirds, the magnitude of impacts for the other special status seabird ranges from **Negligible** to **Small** depending on the impact and the Project stage during which the impact occurs.

The 61 species of special status fishes will have the same exposure to potential impacts as non-special status fishes because their habitat use, behavior patterns, and biology are similar; accordingly, the magnitude ratings for special status species fishes were not changed from those used for non-special status marine fishes (Section 7.8). As described in Section 7.8.3.2, Magnitude and Sensitivity Definitions for Potential Impacts on Marine Fish, the magnitude of impacts on offshore species ranges from **Negligible** to **Small** depending on the impact and the Project stage during which the impact occurs. The magnitude of impacts on coastal species was considered **Negligible**.

Sections 7.4 through 7.8 provide the details for the basis of the magnitude ratings for all taxonomic groups; the magnitude ratings assigned for each impact and conservation status are provided below.

Sensitivity of Receptor—Special Status Species

The sensitivity of special status species to impacts is considered to be higher than that of non-special status species because special status species are assumed to have a diminished capacity to recover from impacts due to their elevated conservation status. With the exception

described below, the designation of sensitivity ratings for special status species is based on the definitions provided in Table 7.1-6.

Table 7.1-6: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Special Status Species

Criterion	Definition
Sensitivity	Negligible: Species with no specific value or importance attached to them.
	Low: Species and sub-species listed as LC on the IUCN Red List (or not meeting criteria for higher IUCN listing status), or without specific anatomical, behavioral, or ecological susceptibilities to potential Project-related impacts.
	Medium: Species listed as VU or NT on the IUCN Red List; species protected under national legislation; nationally restricted range species; regionally important numbers of migratory or congregatory species; species not meeting rating criteria as EN or CR; and species vital to the survival of a medium value species.
	High: Species on IUCN Red List categorized as CR or EN. Species having a locally restricted range, low number of sites where they occur, or highly fragmented population (i.e., endemic species to a site, or found globally at fewer than 10 sites, fauna having a distribution range less than 50,000 square kilometers [19,305 square miles]), internationally important numbers of migratory or congregatory species, species exhibiting or undergoing key evolutionary processes, and species vital to the survival of high value species.

In the case of the resource-specific assessments for marine mammals (Section 7.5) and marine turtles (Section 7.7), the assessments of impact significance assume the affected receptors are all special status species, so the sensitivities for special status marine mammals and marine turtles are identical to those presented in Sections 7.5 and 7.7. In the case of seabirds and marine fish, the resource-specific assessments presented in Section 7.4, Seabirds, and Section 7.8, Marine Fish, are not conducted on the basis of an assumed special status for the receptors. Accordingly, additional review of the sensitivity ratings assigned in Section 7.4 for seabirds and Section 7.8 for marine fish was warranted.

Contrary to other potential impacts, anthropogenic disturbance of turtles at sea (the only potential impact on marine turtles from planned Project activities with a magnitude higher than **Negligible**) is not known to be a major contributor to declines in listed turtle species. Accordingly, the sensitivity rating for this particular impact was not defined based on marine turtles' listing status, but rather on the basis of their anticipated propensity to adapt to occasional disturbance. Increased activity in the PDA and between the PDA and shorebases could cause turtles approaching nesting beaches from the northeast to deviate from their normal migration route, but marine turtles are not known to be particularly sensitive to human activity while at sea and no publicly available research suggests that turtles would be more susceptible to disturbance in the nearshore environment when approaching nesting beaches. Deviation from normal movement patterns would likely be temporary during the disturbance period and would not be expected to result in a significant effect on nesting. On this basis, receptor sensitivity for marine turtles is considered **Low** for this potential impact.

Impact Significance—Special Status Species

As summarized in Table 7.1-8, based on the ranges of magnitudes for potential impacts and the receptor sensitivity ratings applicable for the various IUCN listing levels, the pre-mitigation significance ratings for potential impacts on special status species range from **Negligible** to **Moderate**.

7.1.4. Management Measures—Protected Areas and Special Status Species

The embedded controls integrated into the Project design and operational procedures constitute the practicable measures that are available to reduce the significance of potential impacts on marine fish, marine mammals, seabirds, and marine turtles. Accordingly, no additional mitigation measures are proposed for protected areas and special status species. The same applies for members of these taxonomic groups that carry a special status designation. Table 7.1-7 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 7.1-7: List of Embedded Controls and Monitoring Measures

Embedded Controls
When non-aqueous drilling fluid (NADF) is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.
Employ trained Marine Mammal Observers during the conduct of seismic-related activities.
Conduct a continuous observation of a mitigation zone (500 meters [1,640 feet] around the sound source) to verify whether it is clear of marine mammals and marine turtles before commencing sound producing seismic operations. Do not commence sound-producing seismic operations (including soft starts) if marine mammals or turtles are sighted within the mitigation zone during the 30 minutes prior to commencing sound-producing operations in water depths less than 200 meters (656 feet), or 60 minutes prior to commencing sound-producing operations in water depths greater than 200 meters (656 feet).
Where practicable, equip sound-making devices or equipment with silencers or mufflers that are enclosed, and/or use soft-start procedures (e.g., for pile driving, vertical seismic profiling, etc.) to reduce noise to levels that do not cause material harm or injury to marine species.
Adhere to the Joint Nature Conservation Committee Guidelines (JNCC 2017) during the conduct of seismic-related activities.
During pile-driving activities, gradually increase the intensity of hammer energy to allow sensitive marine organisms to vacate the area before injury occurs (i.e., soft starts).
For all vessel effluent discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage), comply with International Maritime Organization / International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 milligrams per liter (mg/L) on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored, and the discharge meets the noted specification.
Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C (5.4°F) at 100 meters (approximately 328 feet) from discharge point.

Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals
Monitor residual chlorine concentration of sewage discharges form the FPSO monthly to verify it is below 0.5 mg/L in accordance with MARPOL 73/78 regulations.
Perform daily visual inspections on the FPSO of discharge points to verify that there are no floating solids or discoloration of the surrounding waters.
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.
Implement chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances and consider the Offshore Chemical Notification Scheme as a resource for chemical selection in Project production operations. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes; • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.
For effluent released from the onboard sewage treatment plant, comply with aquatic discharge standards in accordance with MARPOL 73/78 regulations.
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter [0.98-inch-diameter] particle size or less) prior to discharge.
Confirm there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge. Perform daily inspections to verify no visible sheen from discharge of cooling water.
Treat bilge water in accordance with MARPOL 73/78 to comply with an oil-in-water content of less than 15 parts per million (ppm), as applicable.
Where reasonably practicable, direct lighting on FPSO and major Project vessels to required operational areas rather than at the sea surface or skyward. Adhere to maritime safety regulations/standards for lighting on vessels.
Provide screening for seawater intakes to avoid entrainment and impingement of marine flora and fauna.
Monitoring Measures
Monitor on an ongoing basis visual detections of marine mammals, riverine mammals, and marine turtles.
Prior to and post-drilling, a remotely operated vehicle will take pictures of the area immediately surrounding the well location to monitor for marine water quality impacts.
Monitor daily during drilling to confirm that end of well maximum weighted mass ratio averaged over all well sections drilled using non-aqueous base fluid shall not exceed 6.9 percent wet weight base fluid retained on cuttings.
Monitor daily produced water discharge volume.
Measure oil and grease content of produced water (grab sample once per day).
Perform daily inspections to verify no visible sheen from discharge of cooling water.
Monitor discharge temperature of cooling water and produced water to avoid increases in ambient water temperature of more than 3°C (5.4°F) at 100 meters (approximately 328 feet) from point of discharge.

Utilize load monitoring system in the FPSO control room to support FPSO offloading.
Monitor pressure and temperature of subsea wells and manifolds by a control system on the FPSO to detect and prevent leaks.
Monitor chlorine concentration of treated sewage discharges.
Perform daily visual inspection of discharge points to verify absence of floating solids or discoloration of the surrounding waters.
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book.
Perform oil in water content (automatic) monitoring of bilge water to comply with 15 ppm MARPOL 73/78 limit and record in Oil Record Book.
Record estimated volume of ballast water discharged and location (per ballasting operation).

Table 7.1-8 summarizes the assessment of potential pre-mitigation and residual Project impacts on special status species. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the special status species-specific methodology described in Section 7.1.3.2 and the resource-specific methodologies described in Sections 7.4, Seabirds; 7.5, Marine Mammals; 7.7, Marine Turtles; and 7.8, Marine Fish. Table 7.1-8 does not include the positive impacts on marine mammals and marine birds because these impacts were not assigned a magnitude rating for non-special status species, but the same positive effects would accrue to special status and non-special status species.

Table 7.1-8: Summary of Potential Pre-Mitigation and Residual Impacts—Special Status Species

Group	IUCN Designation	Range of Magnitude Ratings [a]	Sensitivity Rating	Range of Pre-Mitigation Significance Ratings	Proposed Mitigation Measures	Range of Residual Significance Ratings
Marine Turtles	CR, EN	Negligible to Small	Low to High [b]	Negligible	None	Negligible
	VU	Negligible to Small	Low to Medium [b]	Negligible	None	Negligible
Marine Mammals	VU	Negligible to Medium	Medium	Negligible to Minor	None	Negligible to Minor
Riverine Mammals	VU	Small	Medium	Minor	None	Minor
	NT	Small	Medium	Minor	None	Minor
Marine Fish (Offshore)	CR	Negligible to Small	High	Negligible to Moderate	None	Negligible to Moderate
	EN	Negligible to Small	High	Negligible to Moderate	None	Negligible to Moderate
	VU	Negligible to Small	Medium	Negligible to Minor	None	Negligible to Minor
Marine Fish (Coastal)	CR	Negligible	High	Negligible	None	Negligible
	EN	Negligible	High	Negligible	None	Negligible

Group	IUCN Designation	Range of Magnitude Ratings [a]	Sensitivity Rating	Range of Pre-Mitigation Significance Ratings	Proposed Mitigation Measures	Range of Residual Significance Ratings
	VU	Negligible	Medium	Negligible	None	Negligible
	NT	Negligible	Medium	Negligible	None	Negligible
Seabirds	EN	Negligible	High	Negligible to Minor [c]	None	Negligible to Minor
	VU	Negligible to Small	Medium	Negligible to Minor	None	Negligible to Minor
	NT	Negligible to Small	Medium	Negligible to Minor	None	Negligible to Minor

[a] Magnitude ratings referenced from resource-specific sections (Sections 7.4, Seabirds; 7.5, Marine Mammals; 7.6, Riverine Mammals; 7.7, Marine Turtles; and 7.8, Marine Fish) unless otherwise indicated
[b] Sensitivity rating of Low for potential impacts related to disturbance at sea; IUCN designation-based sensitivity ratings were used for other potential impacts
[c] Although the impact assessment methodology indicates an impact significance rating of Negligible (based on magnitude and sensitivity), a rating of Minor was assigned for attraction-related impacts during the production operations phase of the Project based on the small size and declining population trend of this species (Black-capped Petrel) and the duration of the production operations stage of the Project (20 years) (see Section 7.4, Seabirds).

7.2. COASTAL HABITATS

7.2.1. Administrative Framework—Coastal Habitats

Table 7.2-1 summarizes the legislation, policies, or treaty commitments that are specifically relevant to the assessment of potential impacts on coastal habitats.

Table 7.2-1: Legislation, Policies, or Treaty Commitments—Coastal Habitats

Title	Objective	Relevance to the Project
Legislation		
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013; the Wild Birds Protection Act, 1987; and the Species Protection Regulations, 1999)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a framework to address the national goals for wildlife protection, conservation, and management. The Act also provides recommendations on measures for the protection of threatened ecosystems and habitats, and advises on measures for conservation of biological diversity.

Title	Objective	Relevance to the Project
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity (Signed in 1992, ratified in 1994)	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Encourages Project design and execution so as to protect and conserve biological diversity.
Protocol on Specially Protected Areas and Wildlife (Acceded and Ratified in 2010)	Protocol supplementing and supporting the Cartagena Convention. Requires signatories to adopt an ecosystem approach to conservation. Provides mechanism for compliance with the Convention on Biological Diversity.	Elaborates on the wildlife goals established in the Cartagena Convention and Convention on Biological Diversity.

7.2.2. Existing Conditions—Coastal Habitats

The coastal plain is one of four ecoregions in Guyana: coastal plain, interior savannas, hilly sand and clay, and highland forest (EPA and MoNRE 2014). The coastal plain is a narrow belt of sediments with riverine and marine clays and silts stretching along Guyana's coastline (Figure 7.2-1). It occupies approximately 7 percent of the country's total area and extends along the entire length of the coastline—approximately 400 kilometers (approximately 250 miles)—of the Atlantic coast, varying in width from approximately 16 to 64 kilometers (approximately 10 to 40 miles) (Kalamandeen and Da Silva 2002) and in elevation from sea level to approximately 3 meters (approximately 10 feet) above sea level (EPA and MoNRE 2014).

The coastal plain is a highly productive ecological zone and sensitive, due to the effects of human population growth, periodic flooding, and sea level rise (CPACC 2002; NAERI 1996). Guyana's coastal plain includes a network of plains and low hills, including mangroves, salt to brackish lagoons, brackish herbaceous swamps, and swamp forests. Guyana's coastal plain contains some of the world's most productive ecosystems, with rich biological diversity (Kalamandeen and Da Silva 2002). The swamps are an important source of freshwater to mangroves and other flora and fauna (WWF 2016). The principal habitats along the Guyana shoreline include:

- Mangroves
- Beaches
- Mudbanks
- Tidal flats, including mudflats and sandflats
- Vegetated low banks
- Salt and brackish marshes
- Riprap and exposed solid manmade structures

These habitats are described in the sections below.

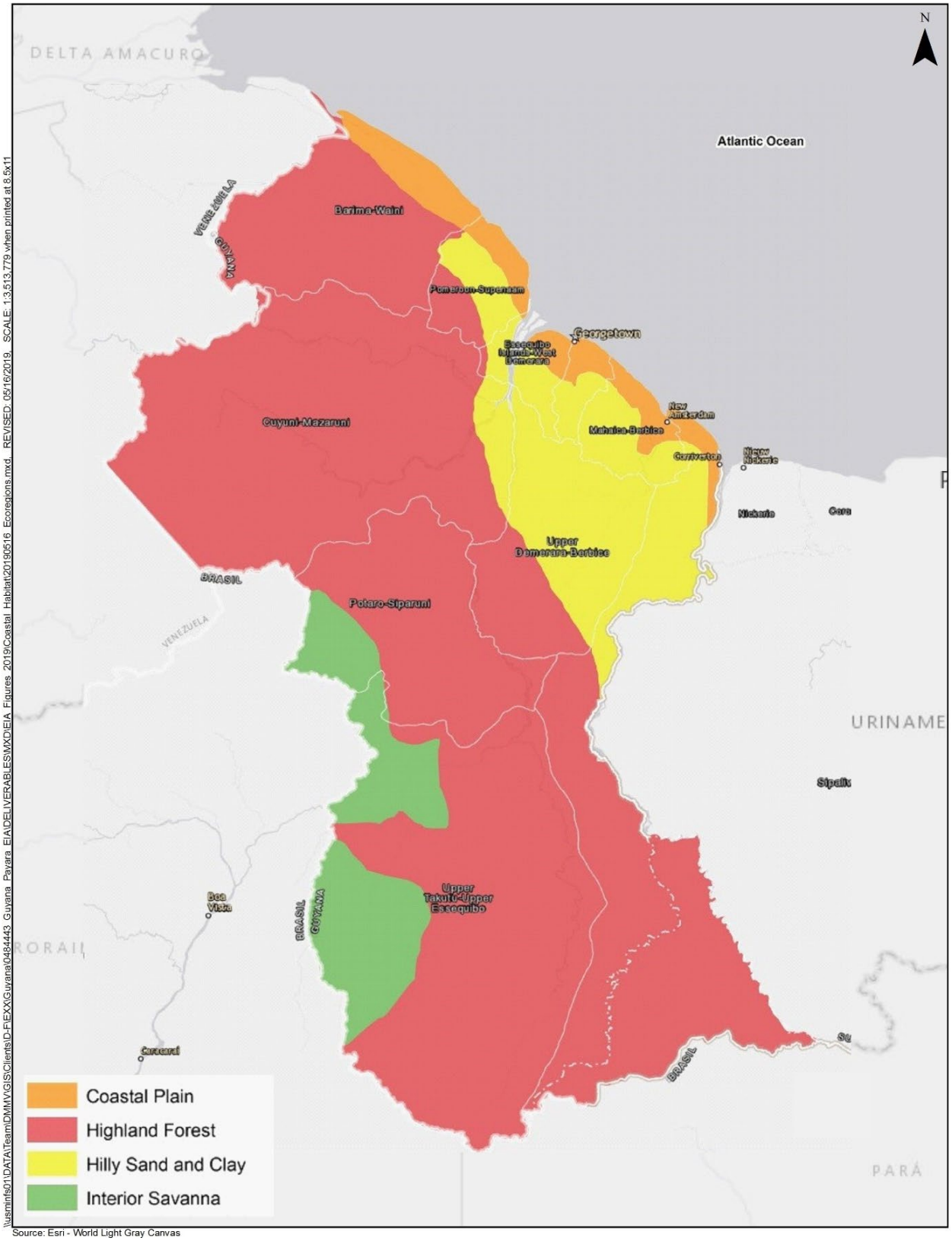


Figure 7.2-1: Guyana's Ecoregions

7.2.2.1. Mangroves

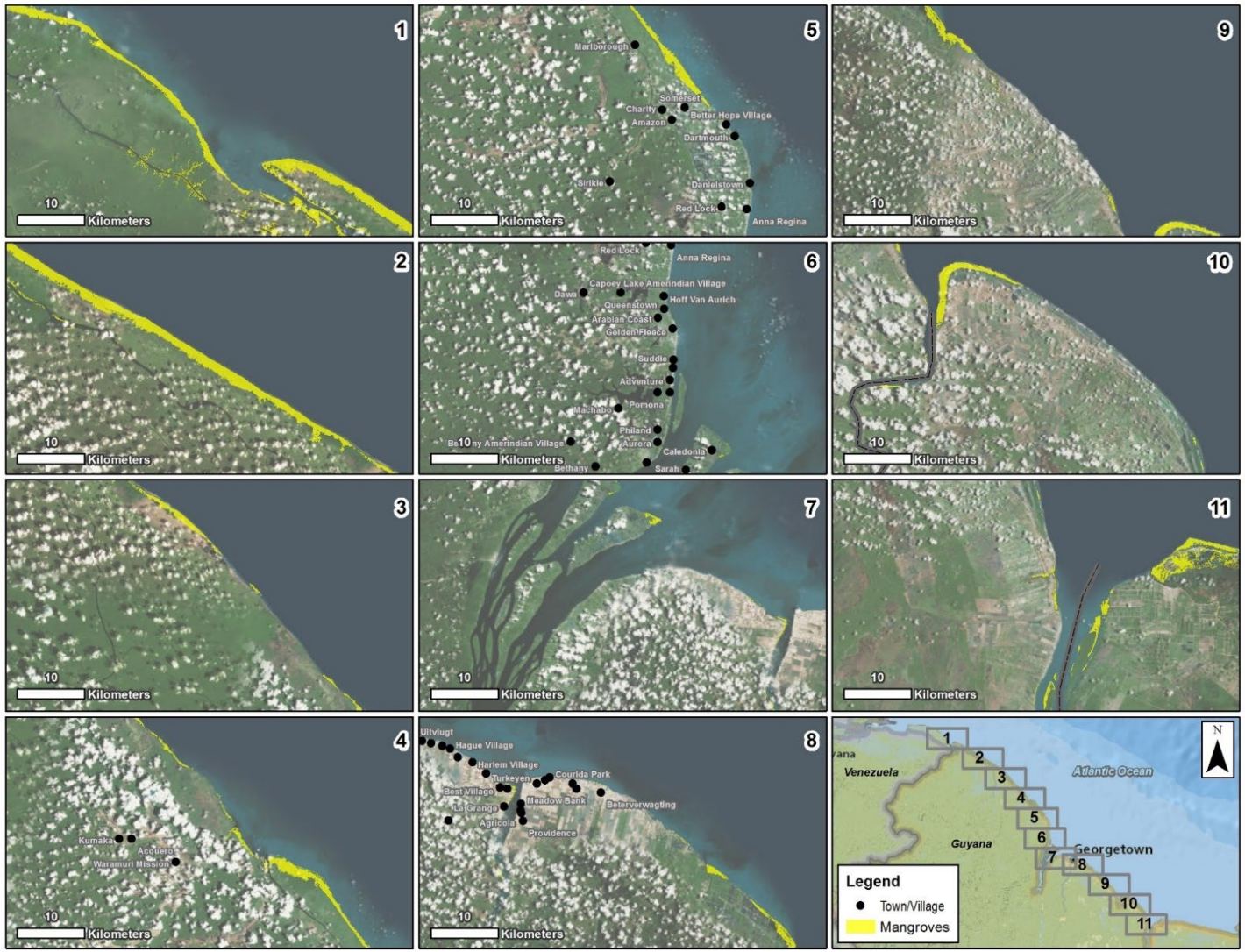
Mangroves are regarded as one of the most important ecosystems for the security of the biodiversity of the entire Guyana coast, particularly Regions 1 and 2, as they protect coastlines from wave action and shoreline erosion (Da Silva 2015) (see Section 6.3.2, Existing Conditions—Marine Geology and Sediments). The distribution of mangroves in Guyana has declined significantly, especially in the last few decades. In 1983, the area of mangroves was reported at 150,000 hectares (approximately 370,657 acres) (Saenger et al. 1983) while in 1992, Guyana's mangrove forest cover had reportedly declined to only 81,000 hectares (approximately 200,155 acres) (GAHEF 1992). A further decline of the total area of mangroves to 22,000 hectares (approximately 54,363 acres) was reported in 2011 (Persaud 2011). The reason for the decline has been traced to various factors, including natural erosion processes and cutting the trees for bark production, fishing poles, agricultural purposes, and wood for fuel. Additionally, the decline of mangrove ecosystems can be attributed to excess siltation due to deforestation, coastal pollution, and changes in freshwater input through damming, channelization, and irrigation (Beckman 2013).

The rate of mangrove decline between 2000 and 2012 is estimated at 4,864 hectares (approximately 12,019 acres) per year; however, a comparison of data on mangrove forest coverage for the entire coastline of Guyana shows an increase of the total area under mangrove from 22,632 hectares (approximately 55,925 acres) in 2011 to 33,361 hectares (approximately 82,437 acres) in 2018 (Conservation International 2018). These data indicate that the trend of declining mangrove coverage that persisted through the late 20th century and early 21st century reversed around 2011, and the mangroves that had been lost since 1992 had been fully replaced by 2018. These recent gains have been mainly due to natural regeneration in some areas exceeding the losses of other parts of the Guyana coastline (Conservation International 2018).

Figure 7.2-2 shows the distribution of coastal mangrove resources in Regions 1 through 6, based on interpretation of satellite imagery[1] and fieldwork conducted in November 2017 and April 2018.

The fieldwork was conducted for all coastal mangroves not blocked by barrier islands (collectively, "the Mangrove Study Area") as part of a broader effort to field-verify the major features of the coastal sensitivity maps (Appendix O, Coastal Sensitivity Maps) that have been developed for EEPGL's exploration and production activities. Although the 2017–2018 fieldwork did not include riverine mangroves, the study did support the conclusion that coastal mangroves are heavily concentrated in the northern portion of the Guyana coastline within Regions 1 and 2. Table 7.2-2 and Figure 7.2-3 summarize the estimated area covered by coastal mangroves in Regions 1 through 6 based on the results of the coastal mapping field verification effort.

[1] Sentinel 2 multispectral imagery from 2017; Google Earth imagery ranging from 2009 to 2017. Sentinel 2 is a European Space Agency mission composed of two satellites that provide wide-swath, high-resolution, multi-spectral imaging. Google Earth aggregates imagery from a variety of publicly available sources.



Note: Yellow shading indicates mangroves.

Figure 7.2-2: Guyana's Coastal Mangrove Distribution

Table 7.2-2: Distribution of Coastal Mangroves in Regions 1 through 6

Region	Area Covered by Mangroves (hectares)	Percentage of Area of All Mangroves in Mangrove Study Area
Region 1	43,170	80.1
Region 2	5,242	9.7
Region 3	1,055	2.0
Region 4	380	0.7
Region 5	1,841	3.4
Region 6	2,215	4.1
TOTAL	**53,904**	**100**

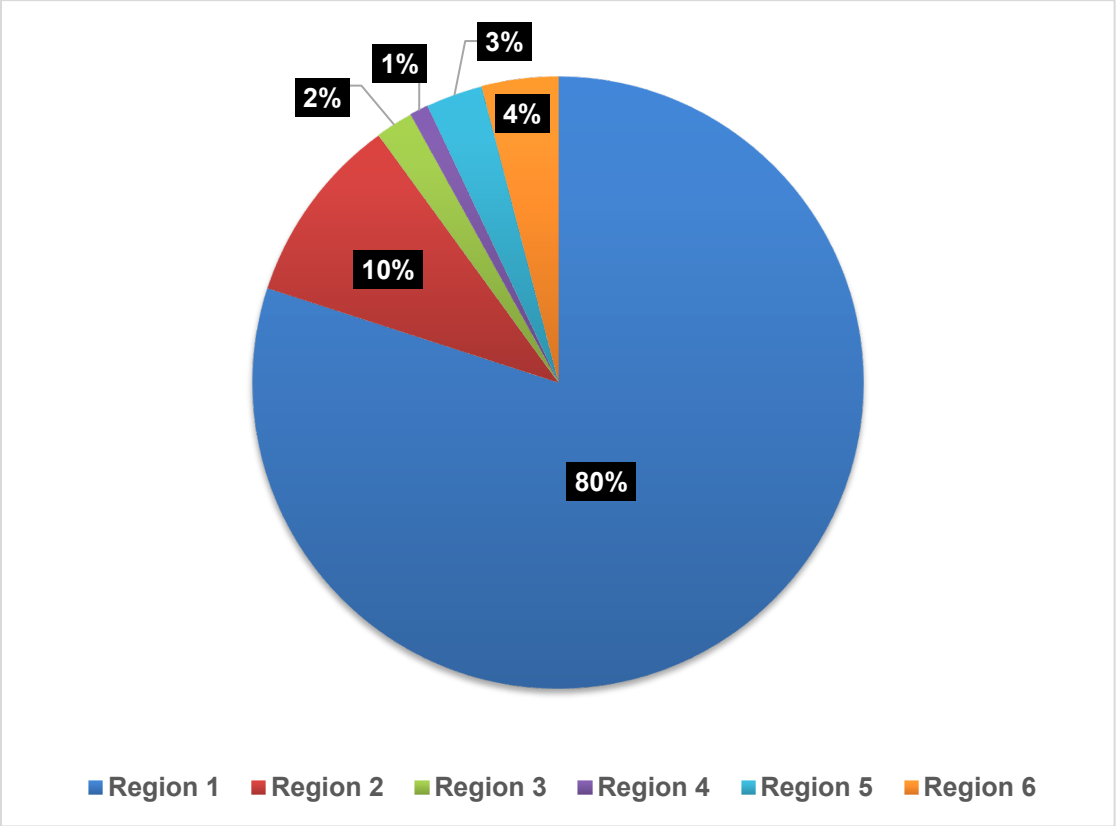


Figure 7.2-3: Distribution of Mangroves in Regions 1 to 6

This study classified mangroves in one of five categories of "sensitivity"[2] based on a combination of relative biomass, mangrove age, and stability (whether it was eroding, stable, or expanding). Figure 7.2-5 is a mosaic of photographs taken during the field verification process showing examples of the five ratings of mangrove sensitivity. Table 7.2-3 and Figure 7.2-4 summarize the results of the mangrove sensitivity assessment in Regions 1 through 6.

[2] The study was conducted in the context of mapping coastal "sensitivities" but with respect to mangroves, the "sensitivity" classification was equivalent to ecological value of the mangroves.

Table 7.2-3: Mangrove Sensitivity Classifications for Regions 1 through 6

Sensitivity Rating	Total Area for Sensitivity Rating (hectares)	Percentage of Area of All Mangroves in Mangrove Study Area
Critical Sensitivity	6,478	12.0
Very High Sensitivity	312	0.6
High Sensitivity	26,122	48.5
Medium Sensitivity	20,000	37.1
Low Sensitivity	992	1.8
TOTAL	53,904	100

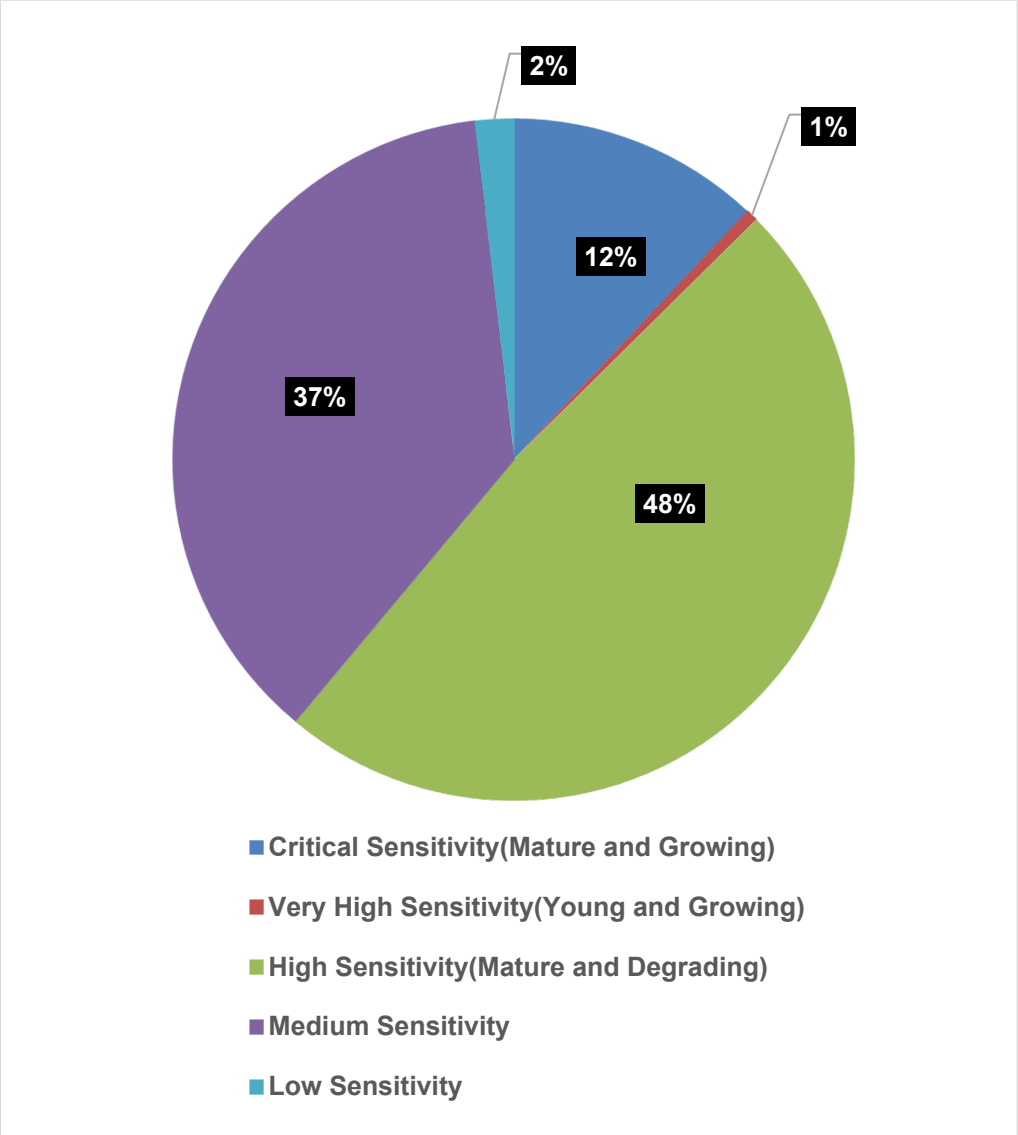


Figure 7.2-4: Sensitivity Ratings for Coastal Mangroves in Regions 1 to 6

Sensitivity Class	Representative Photograph
Critical Sensitivity (high biomass, mature, expanding)	
Very High Sensitivity (high biomass, young, growing/expanding)	

Sensitivity Class	Representative Photograph
High Sensitivity (high biomass, mature, static or degrading)	
Medium Sensitivity (medium biomass, all age classes, static or degrading)	

Sensitivity Class	Representative Photograph
Low Sensitivity (low biomass, all age classes, degrading or eroding)	

Source: ERM 2018b

Figure 7.2-5: Examples of the Five Ratings of Mangrove Sensitivity

There are currently three species of mangrove in Guyana: red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), and white mangrove (*Laguncularia racemosa*). Mangroves in Guyana have a unique distribution pattern that is different from the norm in most other countries. The National Agricultural Research and Extension Institute noted that in Guyana black mangroves typically colonize the coastal shorelines, while red mangroves establish farther inland along rivers (Pastakia 1991; Toorman et al. 2018). White mangroves in Guyana prefer dry, sandy soils. There is some overlap in the typical distribution of these species elsewhere, but in general, the pattern in other countries is for red mangroves to establish along the shoreline, black mangroves to establish farther inland, and white mangroves to establish the farthest inland.

Like most coastal habitats, mangroves are dynamic habitats that are capable of rapid changes over time. As part of the coastal sensitivity verification study, the Consultants analyzed historical imagery to identify areas where mangroves have been lost along the coast. The analysis documented the loss of approximately 1,460 hectares (approximately 3,608 acres) of mangroves since 1980, based on comparison of imagery from 1980 against imagery from 2017. This represents a loss equivalent to 3 percent of the total estimated coastal mangrove coverage in Guyana over a period of slightly less than four decades.

Stakeholder input collected during the preparation of this EIA indicates that recent mangrove losses are evident at the local scale and constitute a worrisome trend for local residents along the coast. Stakeholders in several communities indicated that mangrove coverage had recently decreased within or adjacent to their communities. Most stakeholders attributed these losses to natural processes such as erosion, tidal incursions, or sea level rise, but at least one community (Parika) attributed the loss of local mangroves in the vicinity of their community to coastal development.

Mangrove ecosystems are known to be among the most productive ecosystems in the world (Mann 1982), serving major habitats while providing shelter and feeding sites for many faunal species (Mestre et al. 2007). Coastal mangroves are vital to Guyana's biodiversity, physical security, and economy (WWF 2016; Ilieva Undated). Many invertebrate inhabitants of mangrove ecosystems in Guyana, including snails, barnacles, tunicates, mollusks, polychaete worms, oligochaete worms, shrimp, crabs, sponges, jellyfish, amphipods, and isopods, live either on or in close proximity to mangrove roots and/or the bottom substrate. These small organisms provide forage for birds, mammals, reptiles, amphibians, and fish. Herons, egrets, and ibises are the most conspicuous group of bird species found in mangroves, due to the abundant food sources in a relatively safe habitat (Da Silva 2014).

Mangrove restoration and preservation has been a focus area for Guyana's National Agricultural Research and Extension Institute. In 2019 Conservation International released a report describing the physical and hydrodynamic processes that control mangrove formation along the coast of Guyana and Suriname. This report concluded that recovery and establishment of mangroves, even on reconnected and restored lands, can be hindered by several factors, including:

- Land surfaces falling below the sea elevation at which mangroves establish;
- Increased wave activity in exposed locations; and
- Formation of acid sulfate soils and other changes in soil properties.

The report also concluded that the relationship between sea level rise and increases in suspended sediment from the Amazon River could neutralize or at least mitigate sea level rise impacts in Guyana, which would provide a measure of resilience to their mangroves as long as sea level rise does not outpace sediment accretion. Sedimentation is likely to foster conditions for mangrove reestablishment, but the report also noted that development Infrastructure that establishes the shoreline at a fixed point (such as seawalls for flood protection) exacerbates disappearance of mangroves during the erosion cycle by preventing mangroves to retreat inland as the coastline retreats (Crooks et al. 2019).

7.2.2.2. Beaches

Guyana has relatively few beaches and the largest expanse of beaches in the country lies within the SBPA. The SBPA beaches are critically important nesting habitats for marine turtles. They also provide habitat used by a variety of avian, herptile, and mammalian species (see Figure 7.1-2 for the locations of beaches in the SBPA; see Figure 7.2-6 for a representative photograph of an expanse of beach in Region 2).

Figure 7.2-6: Beach Habitat in Region 2 near the Border with Region 1

7.2.2.3. Mudbanks

"Mudbanks" generally refer to the submerged mud features below the low tide line, as distinct from the intertidal "mudflats" (see Section 6.3.2, Existing Conditions—Marine Geology and Sediments, for a description of the physical attributes and location of Guyana's mudbanks). According to a recent study by Anthony et al. (2013), accretion of muddy sediments discharged from the Amazon River is the most significant natural phenomenon controlling the shape of the coast of South America between the Amazon and Orinoco rivers. About 15 to 20 percent of this muddy discharge forms coastal mudbanks that migrate towards the mouth of the Orinoco River. These mudbanks are characterized by extremely large spatio-temporal geomorphic variability resulting from intense wave-reworking of the migrating banks, mangrove colonization and destruction, and erosion in interbank areas. Approximately 20 percent of the continuous flux of sediments by the Amazon River into the Atlantic Ocean is transported westward along the northern coast of South America (Toorman et al. 2018). Roughly 1.5 million tons is transported yearly by waves as suspended sediment, and another 1.0 million tons per year in the form of large mud banks, which travel at an average speed of roughly 2 kilometers (approximately 1.2 miles) per year in a westerly direction (Nedeco 1968; Allison and Lee 2004).

No targeted biological surveys of Guyana's mudbanks have been conducted to date, but coastal mudbank habitats typically support burrowing invertebrates such as marine worms, mollusks, crustaceans, amphipods, and copepods. This invertebrate community provides important forage for bottom-feeding fishes such as grunts, catfishes, and snappers (particularly during their early life stages).

7.2.2.4. Tidal Flats

There are two main types of tidal flat habitats along Guyana's coastline—mudflats and sandflats. Both of these tidal flat habitats occur in the intertidal zone, so they are submerged under water and exposed twice daily with the tides. The flats are formed by the deposition of mud or sand as a result of the tides. As suggested by their names, mudflats and sandflats are primarily differentiated from one another by their substrates: mudflats have a mud substrate and sandflats have a sand substrate, although due to regular tidal action, these habitats are highly dynamic and there is a continuous gradation between them. The plant and animal communities that are associated with these habitats vary depending on the type and stability of the substrate.

Mudflats

Mudflats are usually barren (without any vegetation) and the mud can range from very soft (almost liquid) to highly compact. Mudflats protect inland landforms from erosion, and they are a highly productive and important ecosystem. Mudflats are often associated with coastal mangroves and salt marshes and these areas together constitute an ecologically important ecosystem for fish and invertebrates, which provide an essential food base for birds, particularly migratory shorebirds that stop-over in Guyana during their bi-annual northward and southward migrations (Reynaud 1990). Each year during spring and fall migration, hundreds (and sometimes thousands) of individual birds stop to feed in Guyana's most extensive mudflats located at Exmouth seaside, Walton Hall seaside, Anna Regina seaside, Ogle seaside, Enmore seaside, Maida seaside and Bush Lot seaside (see Figure 7.2-7, Figure 7.2-8, and Section 7.3, Coastal Wildlife). These mudflats (some with adjacent mangrove habitats) are identified as Important Bird Habitat (IBH) sites due to their importance for migratory shorebirds and resident coastal birds (ERM 2018a).

Figure 7.2-7: Mudflat at Bush Lot Seaside—Important Bird Habitat

Figure 7.2-8: Locations of Important Tidal Flats in Coastal Guyana

Sandflats

Sandflats are similar to mudflats except they are composed primarily of sand rather than mud. They are usually associated with another shoreline type on the landward side of the flat, though they can occur as separate shoals, and they are commonly associated with tidal inlets. When mud accretes on sandflats, a rapid change in the physical structure of the sandflat can occur. Compaction of the sand and mud over time facilitates rapid growth of vegetation, with complete vegetation coverage of the sandflat in potentially less than 1 year. For example, Affiance Seaside in Region 2 changed from an unvegetated sandflat in August 2017 to a fully vegetated sandflat in April 2018 and has continued to persist, currently in the form of black mangroves (see Figure 7.2-9). Vegetated sandflats are ecologically important habitats because they provide food for marine turtles and attract juvenile fish and invertebrates, which are important food sources for birds.

Figure 7.2-9: Vegetated Sandflat at Affiance Seaside in April 2019

7.2.2.5. Vegetated Low Banks

Vegetated low banks are low banks that are covered in grasses, shrubs, or trees with the roots regularly exposed to the water through tides (see Figure 7.2-10).

Note: Tiger Island is in the photo background.

Figure 7.2-10: Vegetated Low Bank along the Region 2 Shoreline

7.2.2.6. Salt and Brackish Marshes

Salt and brackish marshes are intertidal wetlands that consist of emergent, herbaceous vegetation. Depending on inter-annual variations in the amount and location of rainfall and runoff, associated vegetation may include species tolerant of or adapted to salt, brackish, or tidal freshwater conditions. Salt and brackish marshes are often formed in a sheltered area or behind a structure, such as a seawall or groin where water movement slows down—allowing for deposition of mud and growth of vegetation (see Figure 7.2-11). The marsh width may vary widely, from a narrow fringe to an extensive area. Sediments are composed of rich, organic mud except on the margins of islands. Wildlife in saltmarsh and brackish marsh habitats can be abundant and diverse. A wide variety of invertebrates inhabit the mud substrate and fish and shrimp use the vegetation for foraging, sheltering, and laying their eggs. Birds forage on the invertebrates and fish, and nest and roost in the vegetation.

Figure 7.2-11: Saltmarsh Habitat in Region 2 that Developed after the Installation of a Groin

7.2.2.7. Riprap and Exposed Solid Manmade Structures

Riprap structures are composed of cobble to boulder-sized blocks of rock, concrete, and similar materials and are usually used as revetments and groins for shoreline protection and breakwater and jetties around inlets and marinas (see Figure 7.2-12). Exposed solid manmade structures include seawalls, groins, revetments, piers, and port facilities constructed of concrete, wood, or metal. Most of the structures are designed to protect a single lot, thus their composition, design, and condition are highly variable along the coastline. Some biota (primarily macroinvertebrates and aquatic plants) attach themselves to the riprap and other manmade structures, particularly in the lower intertidal zone that receives regular tidal inundation.

Figure 7.2-12: Boulder Riprap at Met-Meer-Zorg in Region 3 in April 2019

7.2.3. Impact Assessment—Coastal Habitats

The planned Project activities, the bulk of which will occur approximately 203 kilometers (126 miles) northeast of the coastline of Georgetown, will not impact any coastal habitats. Operation of the existing Guyana shorebases on the east side of the Demerara River will have little to no impact on coastal habitat. Additional onshore facilities may be used by other companies; any such additional onshore facilities will be owned/operated by others and will not be dedicated to the Project. For any new or expanded shorebase, or onshore support facility, the construction/expansion and any required dredging of such facilities, as well as the associated environmental authorizations, would be the responsibility of the owner/operator, and such work scope is therefore not included in the scope of the Project EIA.

The Project's only potential impact on coastal habitats would be as a result of an unplanned event (i.e., an oil spill), which is discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

7.2.4. Management Measures—Coastal Habitats

As the planned activities of the Project are not anticipated to impact any coastal habitats, no mitigation measures associated with planned activities are proposed. Mitigation measures to address potential impacts on coastal habitats from an unplanned event are discussed in Chapter 9.

7.3. COASTAL WILDLIFE

7.3.1. Administrative Framework—Coastal Wildlife

Table 7.3-1 summarizes the legislation, policies, or treaty commitments that are specifically relevant to the assessment of potential impacts on coastal wildlife.

Table 7.3-1: Legislation, Policies, or Treaty Commitments—Coastal Wildlife

Title	Objective	Relevance to the Project
Legislation		
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013; the Wild Birds Protection Act, 1987; and the Species Protection Regulations, 1999)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a framework to address the national goals for wildlife protection, conservation, and management. The Act also provides recommendations on measures for the protection of threatened ecosystems and habitats, and advises on measures for conservation of biological diversity.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity (signed in 1992 and ratified in 1994)	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Encourages Project design and execution to protect and conserve biological diversity.

7.3.2. Existing Conditions—Coastal Wildlife

Guyana occupies the west-central portion of the Guianan mangrove ecoregion, which extends from southeastern Venezuela southeast to French Guiana between the Orinoco River Deltas and the Oyapok River Delta in French Guiana. The ecoregion is a bio-geographical, rather than geopolitical, region and was designated as a distinct ecoregion by the World Wildlife Fund as part of their Terrestrial Ecosystems of the World project (Olson et al. 2001). Despite supporting more than 90 percent of the country's human population, Guyana's coastal region supports a diverse fauna. This section briefly describes bird, mammal, and herpetofauna (reptile and amphibian) species that are representative of Guyana's coastal region.

7.3.2.1. Coastal Mammals and Herpetofauna

Numerous mammal and herpetofauna species occur in Guyana's coastal mangroves, agricultural areas, and forests. There are more than 50 species of mammals present, including opossums; bats; primates such as capuchin monkey (*Cebus apella*), squirrel monkey (*Saimira sciureus*), howler monkey (*Alouatta seniculus*), and Guianan saki (*Pithecia pithecia*); giant anteater (*Myrmecophaga triactyla*); several species of cats including jaguar (*Panthera onca*), puma (*Puma concolor*) (Figure 7.3-1), and ocelot (*Leopardus pardalis*); ungulates (hoofed

mammals); and rodents including the capybara (*Hydrochaeris hydrochaeris*), paca (*Agouti paca)*, and red-rumped agouti (*Dasyprocta leporina*); red and grey brocket deer (*Mazama* sp.); giant river otter (*Pteronura brasiliensis*), which is a freshwater species; and neotropical otter (*Lontra longicaudis*), which is found in both freshwater and estuarine habitats. Reptiles that frequent this ecoregion are the green iguana (*Iguana iguana*), spectacled caiman (*Caiman crocodilus)*, and green anaconda (*Eunectes murinus*). Amphibians are generally less common along the coast than in the interior, especially due to saline influence in the mangroves, but some of the species that occur along the coast include several species of tree frogs (*Hyla* sp.), the paradoxical frog (*Pseudis paradoxa*), cane toad (*Rhinella marina*), and pipa frog (*Pipa pipa*).

Figure 7.3-1: Puma (*Puma concolor*) Swimming across Baramanni Creek, Region 1

No comprehensive, targeted surveys for mammals or herpetofauna along Guyana's coast have been conducted. Two biodiversity surveys have been undertaken within and around the SBPA over roughly the past decade, and these surveys included documentation of 27 mammal and 41 herpetofauna (28 reptile and 13 amphibian) species, including many of those listed above (Mendonca et al. 2006; EPA et al. 2004; Appendix P, Flora and Fauna of Shell Beach). Incidental observations of mammals documented during EEPGL-commissioned coastal bird surveys in 2017, 2018, and 2019 (see Section 7.3.2.2, Coastal Birds, for a detailed description of these surveys) documented some of the species above and also Guianan red howler monkey (*Aloutta macconnelli*), wedge-capped capuchin monkey (*Cebus albifrons*), Indian grey mongoose (*Herpestes edwardsi*), and crab-eating raccoon (*Procyon cancrivorus*) (Figure 7.3-2).

Photo credit: Waldyke Prince

Figure 7.3-2: Crab-eating Raccoon (*Procyon cancrivorus*) Observed at Phillipe Seaside in Region 6, April 2019

EEPGL commissioned a targeted survey of riverine mammals in early 2019 through early 2020 in the area between the Demerara Harbour Bridge and the mouth of the Demerara River. American manatee (*Trichechus manatus*) was the only species of riverine mammal recorded during the study period. A total of 14 individuals were observed over the study period, most of which were solitary individuals; however, a mother and calf were sighted together on 7 February 2020. Figure 7.3-3 depicts the number of individual manatees sighted by survey date. Figure 7.3-4 depicts a map showing the location of each manatee sighting (2019–2020)[3].

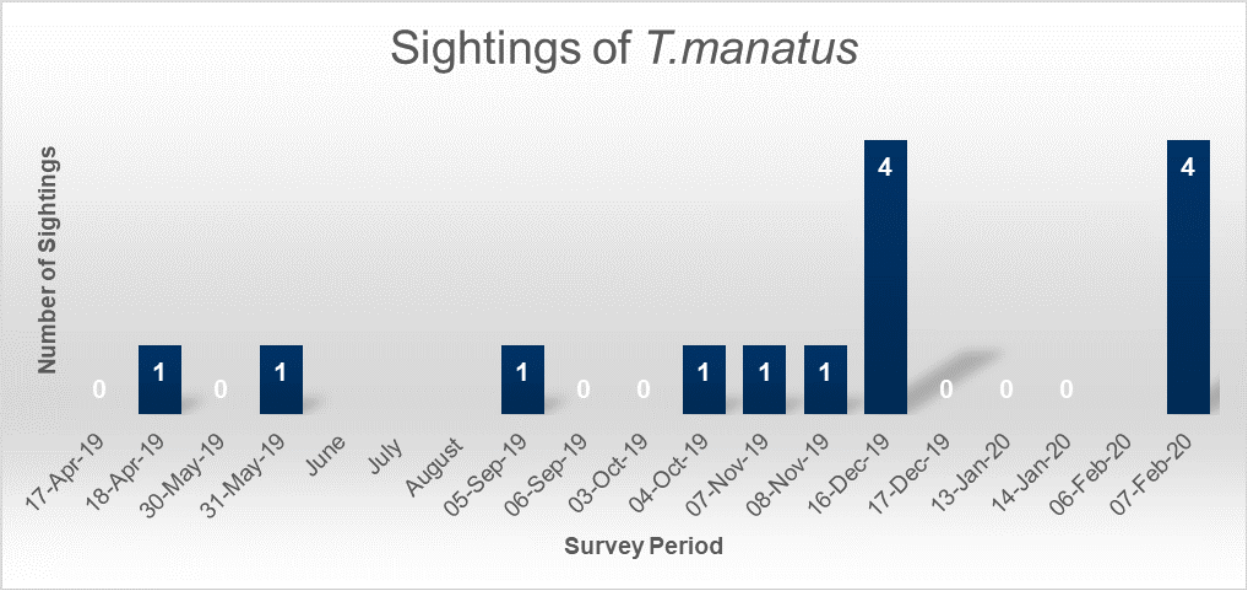


Figure 7.3-3: American Manatee (*Trichechus manatus*) Sightings over the Survey Period (2019–2020)

[3] Figure 7.3-3 indicates 14 sightings because it identifies individual animals sighted. Figure 7.3-4 indicates 13 sightings because it identifies sighting events rather than individuals sighted, and a mother and calf were sighted together during the same event on 7 February 2020.

Figure 7.3-4: Locations of Manatee Sightings within the Lower Demerara River (2019–2020)

7.3.2.2. Coastal Birds

Historical Data

Guyana's coastal bird community is abundant and diverse. Numerous groups are represented, including parrots and macaws, passerines, waterfowl, colonial waterbirds, shorebirds, and raptors. The bird groups that are most strongly affiliated with the coast are waterfowl, shorebirds, and colonial waterbirds. Waterfowl are species of birds that are ecologically dependent upon wetlands or waterbodies for their survival (e.g., ducks, geese, etc.). Shorebirds are found mainly on beaches and mudflats between the low and high water marks and are typically migratory, using Guyana's coastline during the course of their bi-annual migrations. Colonial waterbirds are birds that live near water and nest in colonies or groups (e.g., gulls, terns, ibis, herons, etc.).

Braun et al. (2007) developed a comprehensive checklist of the 814 bird species within 11 habitats documented in Guyana. The coastal habitats surveyed include mangrove forests (47 species documented within 18 families) and mudflats (38 species documented within 8 families; Braun et al. 2007). Another coastal bird survey conducted along the coast in the Georgetown region by Bayney and Da Silva (2005) documented 32 coastal bird species, 20 of which are migrants. The most abundant species documented in the survey were shorebirds including Least Sandpiper (*Calidris minutilla*), Spotted Sandpiper (*Actitis malcularia*), Ruddy Turnstone (*Arenaria interpres*), and Semipalmated Plover (*Charadrius semipalmatus*). Waterbird species including Cattle Egret (*Bulbulcis ibis*) and Snowy Egret (*Egretta thula*) were also abundant. A more recent bird survey within coastal mangrove habitats in southeast Guyana identified 37 species within 14 families (Da Silva 2014). In this 2014 survey, the most abundant species recorded were the Great Egret (*Ardea alba*), Greater Kiskadee (*Pitangus sulphuratus*), Pied Water Tyrant (*Fluvicola pica*), Rufous Crab-hawk (*Buteogallus aequinoctialis*), and Scarlet Ibis (*Eudocimus ruber*) (Da Silva 2014).

Two biodiversity surveys undertaken within the SBPA over roughly the past decade documented more than 200 bird species in the Shell Beach area, including many forest interior species that occur in the inland habitats of Shell Beach (Mendonca et al. 2006; EPA et al. 2004) (Appendix P, Flora and Fauna of Shell Beach). Many of these species are migrants that travel from the United States and Canada to spend the winter season in Guyana, primarily following the Atlantic and Central Flyways to South America. The most abundant coastal species recorded at and around Shell Beach during the two surveys included Black-bellied Whistling-duck (*Dendrocyna autumnalis*),[4] Laughing Gull (*Larus atricilla*), Least Tern (*Sterna antillarum*), Spotted Sandpiper, Lesser Yellowlegs (*Tringa flavipes*), Scarlet Ibis, and Yellow-billed Tern (*Sterna superciliaris*) (Mendonca et al. 2006; EPA et al. 2004).

Collectively, species accounts from all these reports document the presence of 95 species of coastal birds from 32 families in Guyana. Another 113 species of non-coastal birds have been documented in inland habitats of the SBPA (Mendonca et al. 2006; EPA et al. 2004). These

[4] Recorded as a freshwater species in Braun et al. 2007

113 species occasionally occur in coastal areas as transients, but are not expected to occur there regularly, so are not considered coastal birds.

Coastal Bird Survey Data Collected from 2017 to 2020

EEPGL commissioned a series of seasonal coastal bird surveys along the Guyana coast between 2017 and 2020 (Appendix L, Coastal Bird Survey Report: Coastal Bird Study 2017–2020). Surveys of coastal birds were conducted across six regions by teams of international and Guyanese bird specialists in the following time periods and locations:

- Fall 2017 Survey: Occurred 23 to 27 September 2017 and 19 to 22 October 2017 at coastal sites in Regions 2-5 and the Essequibo Islands
- Spring 2018 Survey: Occurred 3 to 13 April 2018 and 16 to 24 April 2018 at coastal sites in Regions 1-6 and the Essequibo Islands
- Fall 2018 Survey: Occurred 14 to 15 September 2018 and 30 September to 3 October 2018 at coastal sites in Regions 2 through 6 and the Essequibo Islands
- Winter 2019 Survey: Occurred 22 January to 2 February 2019 at coastal sites in Regions 2 through 6 and the Essequibo Islands
- Spring 2019 Survey: Occurred 27 March to 4 April 2019 at coastal sites in Regions 2 through 6 and the Essequibo Islands
- Summer 2019 Survey: Occurred 21 to 28 June at coastal sites in Regions 2 through 6 and the Essequibo Islands
- Fall 2019 Survey: Occurred 30 September to 10 October 2019 at coastal sites in Regions 2 through 6 and the Essequibo Islands
- Winter 2020 Survey: Occurred 25 January to 5 February 2020 at coastal sites in Regions 2 through 6 and the Essequibo Islands

A total of 118 sites were surveyed throughout Regions 1 through 6 during the EEPGL-commissioned coastal bird surveys from 2017–2020 (Figure 7.3-5 and Table 7.3-2). Some sites were not sampled in 2017 because the scope of the surveys in 2017 only included Regions 2 through 5. Also, additional survey sites were added in 2018 and 2019 in Regions 2 and 6 and in 2019, the number of Essequibo Island survey points was reduced to optimize survey coverage of these areas.

The 2017–2020 coastal bird surveys documented a total of 225 species and more than 109,471 birds across all regions and survey sites. Coastal sites accounted for 211 species and island sites accounted for 145 species, with 130 species found at both coastal and island sites. Appendix L, Coastal Bird Survey Report: Coastal Bird Study 2017–2020, lists all of the species observed in each region during the EEPGL-commissioned surveys conducted to date. All of the species documented during the 2017–2020 surveys have been previously recorded in Guyana, although many species (19) were newly documented in the coastal regions of the country. These new occurrences are likely due to the lack of documented comprehensive surveys of coastal birds along the Guyana coast prior to these surveys.

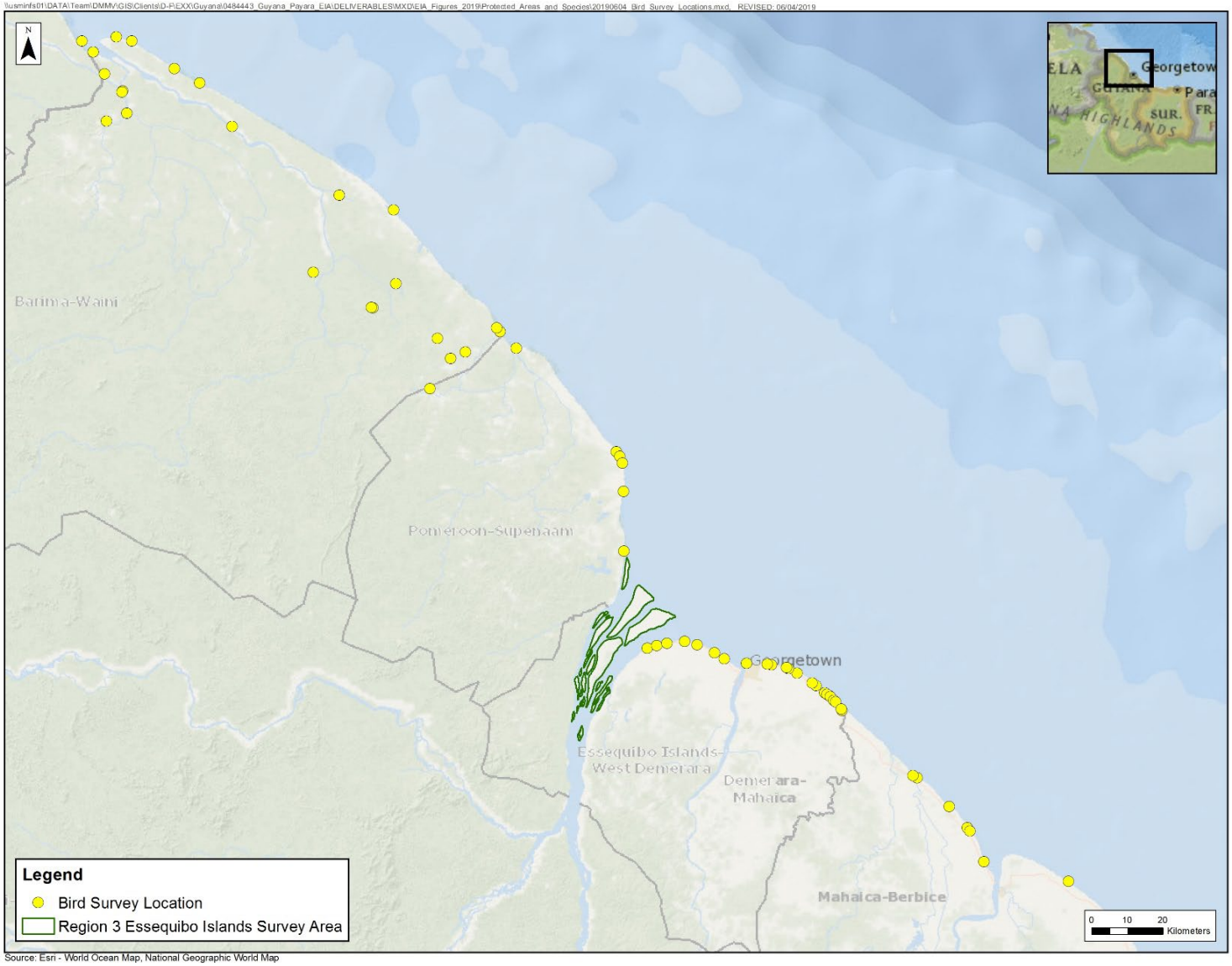


Figure 7.3-5: Coastal Bird Survey Sites Surveyed in 2017–2020

Table 7.3-2: Number of Coastal Bird Sampling Sites by Region for each Sampling Period (2017–2020)

Region	Fall 2017	Spring 2018	Fall 2018	Winter 2019	Spring 2019	Summer 2019	Fall 2019	Winter 2020	Total [a]
1	NS	18	NS	NS	NS	NS	NS	NS	18
2	5	6	6	6	6	7	7	7	7
3 (Coastal)	3	3	7	7	7	7	7	7	7
3 (Essequibo Islands)	32	50	52	51	27	27	27	27	52
4	20	20	16	16	16	12	12	12	20
5	6	6	6	6	6	6	6	6	6
6	NS	5	5	5	8	8	8	8	8
Total	66	108	92	91	70	67	67	67	118

NS = not sampled
[a] Total unique sites surveyed from all surveys conducted between September 2017 and March 2020

Further, while these surveys documented many more species than previously recorded in Guyana's coastal habitats (225 versus 208), some species previously known to occur along the Guyana coast, based on historical records, were not documented during the 2017–2020 surveys; therefore, the coastal bird community likely has even higher bird species richness (number of species) than documented in the 2017–2020 surveys. The most common shorebirds observed during the 2017–2020 surveys (more than 1,000 individuals each) included one species of nearshore marine bird (Black Skimmer [*Rynchops niger*]), five species of waterbirds (Great Egret, Little Blue Heron [*Egretta caerulea*], Scarlet Ibis, Snowy Egret, and Tricolored Heron [*Egretta tricolor*]), three species of shorebirds (Lesser Yellowlegs, Semipalmated Plover, and Semipalmated Sandpiper [*Calidris pusilla*]), one species of migratory landbird (Barn Swallow [*Hirundo rustica*]), and two species of non-migratory landbirds (Gray-breasted Martin [*Progne chalybea*] and Great Kiskadee). Of particular note, Barn Swallow was a dominant species in all fall coastal bird surveys (2017, 2018, and 2019). This species also was a dominant species observed offshore Guyana during concurrent EEPGL-commissioned marine bird surveys in fall 2018 and fall 2019. The observance of large numbers of this species both offshore and onshore during the same time period in successive years is a strong indication of the fall migratory period for this species through Guyana, which was unknown prior to the surveys. Figures 7.3-6, 7.3-7, and 7.3-8 include photographs of birds taken during the coastal bird surveys (see Appendix L, Coastal Bird Survey Report: Coastal Bird Study 2017–2020, for additional photographs).

Figure 7.3-6: Little Blue Heron (*Egretta caerulea*) Observed at Ogle Seaside in Region 4

Figure 7.3-7: Lesser Yellowlegs (*Tringa flavipes*) on the Shoreline at Anna Regina in Region 2

Photo credit: Waldyke Prince

Figure 7.3-8: Scarlet Ibis (*Eudocimus ruber*) Foraging in the Mangroves in Region 6, February 2019

Average bird abundance varied by season and region. The Summer 2019 survey recorded the lowest average abundance across all regions (Figure 7.3-9 and Table 7.3-3); this is likely due to the fact that many migrants are not present in Guyana during the summer months. There was moderate variation in average abundance across all regions during spring and fall surveys; surveys with higher abundance (e.g., Region 6 in Fall 2018; Table 7.3-3 and Figure 7.3-9) recorded large numbers of migrants, typically occurring in large groups. Outside the seasonal migration peaks, Region 5 had the highest average abundance across survey periods (Table 7.3-3 and Figure 7.3-9). Several sites in this region contain mudflats and coastal mangroves that provide important foraging, roosting, and breeding habitat for many coastal birds in Guyana. In general, Region 3 had much lower average abundance (at both island and coastal sites) across all surveys than other regions. Despite having lower average abundance, data from these sites are particularly important to document the full range of coastal species present in Guyana. These Region 3 sites, particularly the Essequibo Islands sites, have unique riverine mangrove habitat that support species not recorded in any of the other regions.

One survey event of note is the Fall 2018 survey, which likely coincided with peak migration given the consistently high bird abundance across most of the regions. Region 6 had more than 2,000 birds per site during this survey, on average (Table 7.3-3 and Figure 7.3-9.

Table 7.3-3: Average Per-Site Bird Abundance for 2017–2020 Surveys by Region

Region	Fall 2017	Spring 2018	Fall 2018	Winter 2019	Spring 2019	Summer 2019	Fall 2019	Winter 2020
1	NS	144	NS	NS	NS	NS	NS	NS
2	402	298	546	171	271	100	249	409
3—Coastal	63	32	62	105	69	49	30	43
3—Islands	43	342	237	14	11	21	24	12
4	279	165	207	273	152	139	392	264
5	180	953	778	605	522	112	802	1,805
6	NS	363	2,047	711	268	89	408	297

NS = not sampled
[a] Data for 2018 island surveys were provided by island sites as a group rather than individual survey points.

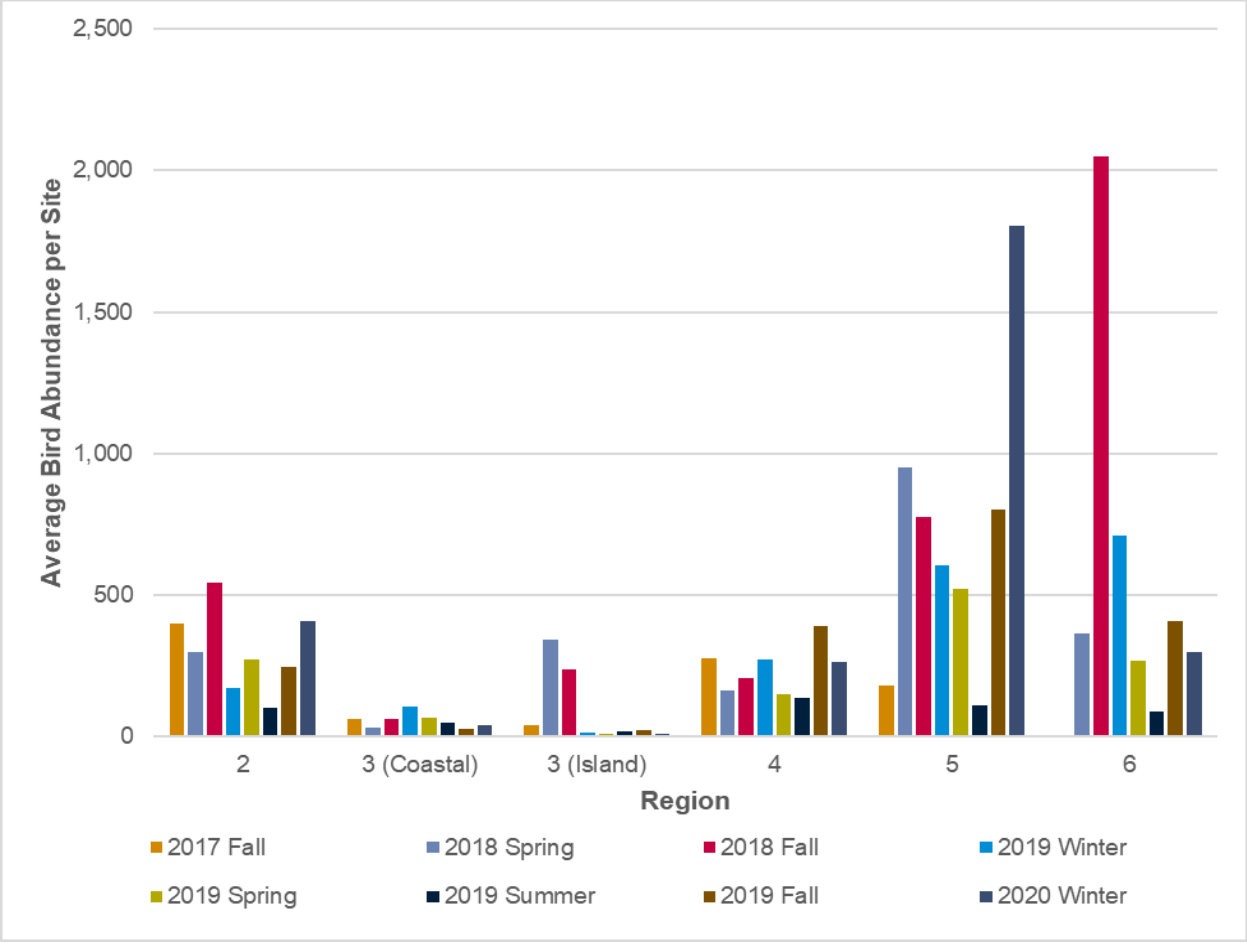


Figure 7.3-9: Average Bird Abundance per Site, by Region and Survey Period

Average species richness varied less than abundance across survey periods and regions. There were no clear seasonal patterns in species richness, with all coastal (i.e., non-island) surveys ranging between 11 and 21 species per site on average (Table 7.3-4 and Figure 7.3-10). Aside from two island surveys (Region 3), Region 5 generally had the highest species richness (Table 7.3-4 and Figure 7.3-10). Sites in this region contain extensive mudflat and mangrove habitats that attract a diversity of species throughout the year. The Region 3 island sites typically had lower species richness than other regions, except during the Spring and Fall 2018 surveys, which recorded the two highest average species richness of the entire study (24 and 30 species per site, respectively; see Table 7.3-4 and Figure 7.3-10). The comparatively lower species richness and abundance totals in this region (e.g.; Summer 2019 through Winter 2020) are due to the number of sites surveyed along the entire coast on each island. There were typically around 50 island sites surveyed during each period, which is a larger number than in the other regions. This distribution of effort in Region 3 resulted in more sites with few or no birds at the time of survey than in other regions, often as a byproduct of tide or other conditions. The high average species richness in Region 1 in Spring 2018 is likely due to the survey area covering a greater diversity of habitats, including more inland habitats than the other regions (i.e., riverine mangroves, wetlands, and riverine forests, which are rare or absent in the coastal survey sites in Regions 2 through 6).

The island sites have different habitats than the coastal areas, and therefore have unique bird species assemblages. Fifteen species were only documented at island sites during the entire survey. Many of the species unique to the island sites are inland species such as hawks, woodpeckers, and flycatchers.

Table 7.3-4: Average Per-Site Species Richness for 2017–2020 Surveys by Region

Region	Fall 2017	Spring 2018	Fall 2018	Winter 2019	Spring 2019	Summer 2019	Fall 2019	Winter 2020
1	NS	23	NS	NS	NS	NS	NS	NS
2	18	16	19	13	15	12	16	13
3—Coastal	20	11	14	17	14	14	11	11
3—Islands	10	24	30	6	5	5	7	4
4	19	14	16	12	14	16	16	14
5	17	18	21	18	18	21	18	17
6	NS	12	15	15	15	16	15	12

NS = not sampled
[a] Data for 2018 island surveys were provided by island sites as a group rather than individual survey points.

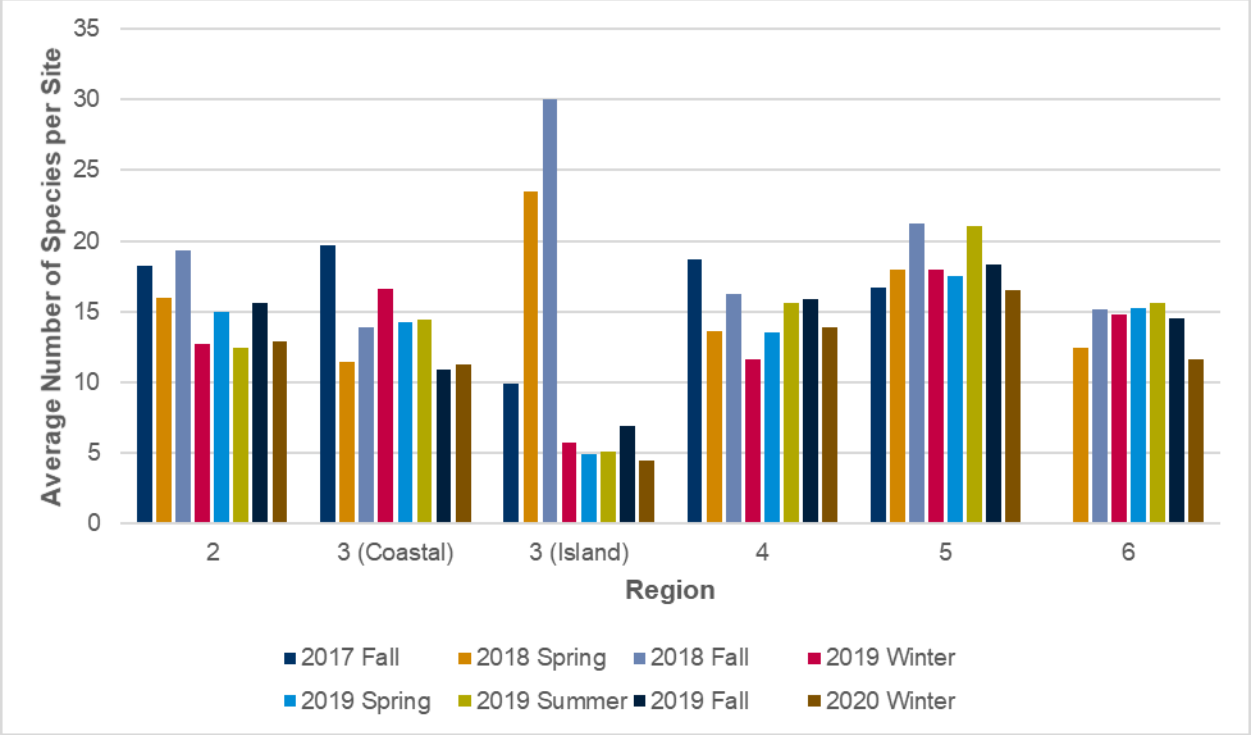


Figure 7.3-10: Average Species Richness per Site, by Region and Survey Period

7.3.2.3. Important Bird Habitats for Coastal Birds

BirdLife International (2016) has designated several Important Bird Areas (IBAs) in the neighboring countries of Suriname, Trinidad and Tobago, and Venezuela. These IBAs provide foraging, breeding, and nesting habitats similar to those found along Guyana's coastline. While no IBAs have been designated in Guyana, several areas along the Guyana coastline meet the definition of a "threshold site" by BirdsCaribbean (www.birdscaribbean.org) for high abundance (criterion for threshold site is more than 3,000 individuals), which is consistent during coastal bird migration periods (ERM Personal Communication 25).

Fourteen coastal IBH sites were identified within Regions 1 through 6 in 2018, based on the EEPGL-commissioned coastal bird surveys in 2017 and 2018 (Appendix L, Coastal Bird Survey Report: Coastal Bird Study 2017–2020) as well as other available data from historical surveys, and local bird specialists' knowledge (Figure 7.3-11, Figure 7.3-12, and Table 7.3-5). These IBH sites support one or more of the following: (1) predictable congregations of migratory shorebirds, including threshold sites; (2) concentrations of roosting and/or nesting wading birds; (3) unique habitat that supports large numbers of riverine forest- and mangrove-dependent species; and (4) important nesting sites for regional endemic species of conservation interest.

Photo credit: Waldyke Prince

Figure 7.3-11: Wading Birds and Shorebirds Feeding on Mudflat Habitat at the Exmouth Seaside Important Bird Habitat, January 2019

Data from the EEPGL-commissioned coastal bird surveys that occurred after the initial designation of the 14 IBH sites validate their designation, as all previously identified IBH sites consistently had higher average bird abundance and species richness per site than other survey locations. Coastal IBH sites had an average abundance of 890 birds and 21 species per site across all surveys conducted to date, more than double that of non-IBH sites.

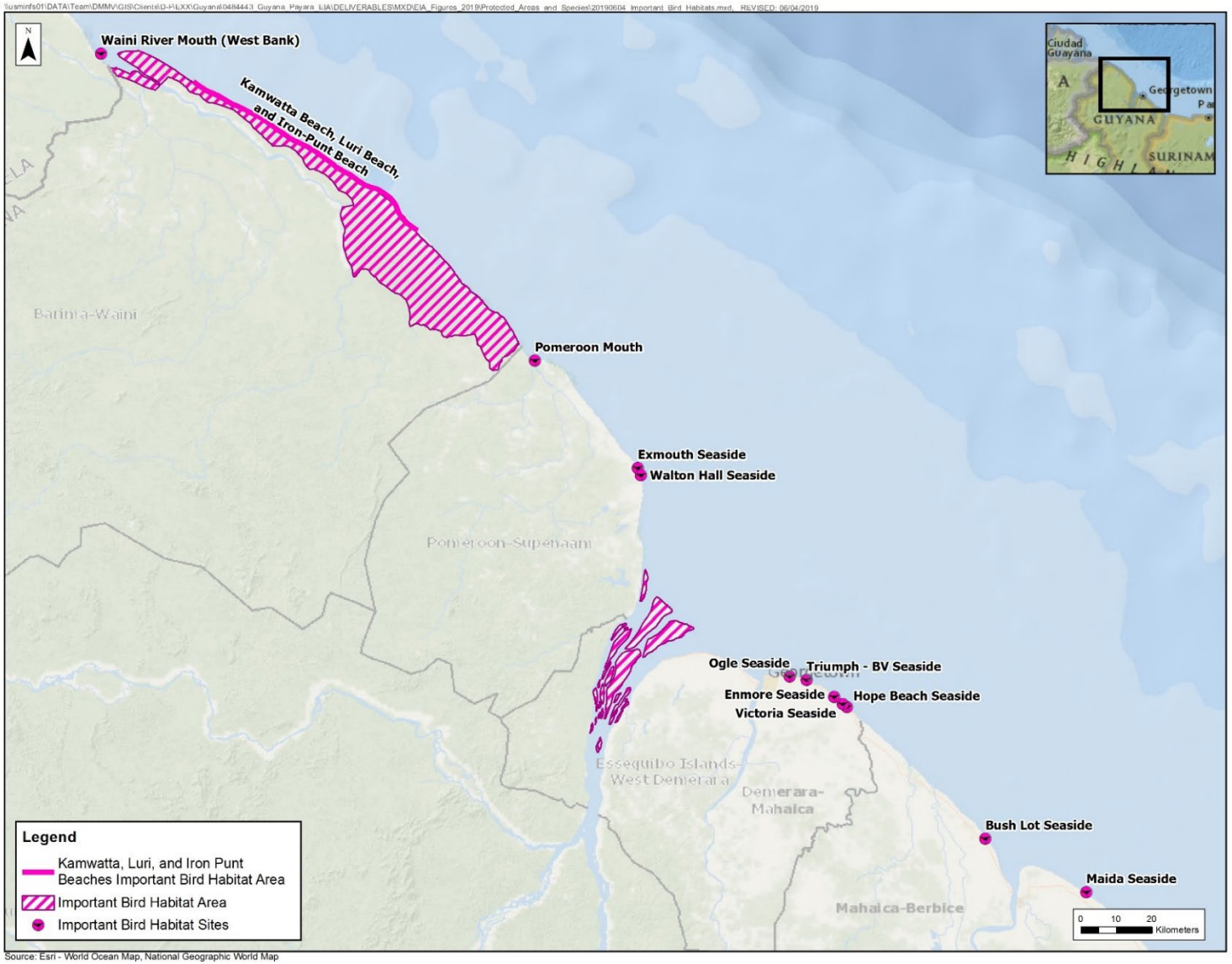


Figure 7.3-12: Locations of Important Bird Habitats—Regions 1 through 6

Table 7.3-5: Important Bird Habitats Identified in Regions 1 through 6

Important Bird Habitat	Region	Primary Bird Habitat	Rationale for Designation as Important Bird Habitat	Photograph
Shell Beach Protected Area	1	Sandy beach, mudflat, mangrove	SBPA contains critically important nesting and foraging habitats for over 200 species of waterbirds and land birds, including several globally threatened species.	
Pomeroon River Mouth	1	Mudflat, mangrove	Extensive tidal mudflat that is an important congregation and foraging site for shorebirds and wading birds. Thousands of wading birds roost in the mangroves in this area.	
Kamwatta Beach, Iron Punt Beach, and Luri Beach	1	Sandy beach, mudflat, mangrove	These beaches host hundreds of flamingos (multiple species) and thousands of other colonial waterbirds (ERM Personal Communication 26) for nesting and feeding. The photo depicts Luri Creek, which is located just inland from Luri Beach and is the location of the colonial waterbird roosting and nesting site.	

Important Bird Habitat	Region	Primary Bird Habitat	Rationale for Designation as Important Bird Habitat	Photograph
Waini River Mouth (west bank)	1	Mangrove	Pristine mangrove forest supporting large congregations of colonially roosting and nesting wading birds (herons, egrets, ibis, etc.).	
Exmouth Seaside	2	Mudflat	Extensive tidal mudflat that is an important congregation and foraging site for shorebirds and wading birds, including over 3,000 shorebirds (*Calidris* sp.) at a time, qualifying it as a threshold site[5] during the migratory season.	
Walton Hall Seaside	2	Mudflats and mangrove	Tidal mudflats and mangroves supporting large congregations of shorebirds and wading birds.	

[5] BirdsCaribbean's definition of a Threshold Site for migratory birds is one that is known or thought to hold congregations that are equal to or more than 1 percent of the global population of one or more species (including species group or family) on a regular or predictable basis.

Important Bird Habitat	Region	Primary Bird Habitat	Rationale for Designation as Important Bird Habitat	Photograph
Essequibo Island Complex	3	Mangrove	Unique transition zone between riverine forest and mangrove ecosystems that provides important roosting and nesting habitat for riverine birds and wading birds.	
Ogle Seaside	4	Mudflat	Extensive mudflat that is heavily populated with foraging shorebirds (more than 3,000 individuals at a time, qualifying it as a threshold site for *Calidris* sp.) during the migratory season.	
Triumph-BV Seaside	4	Mudflat and mangrove	Extensive mudflat and natural revegetation of mangroves that supports large numbers of migratory shorebirds and waterbirds and is also considered very important as a nesting site for Snail Kite (*Rostrhamus sociabilis*).	

Important Bird Habitat	Region	Primary Bird Habitat	Rationale for Designation as Important Bird Habitat	Photograph
Enmore Seaside	4	Mudflat and mangrove	Tidal mudflats and mangroves that host large congregations of shorebirds and wading birds, and serve as nesting site for Snail Kite (*Rostrhamus sociabilis*) and other mangrove-dependent species including conebills	
Hope Beach Seaside	4	Vegetated sand flat	Fine sand flats overlain with compact mud at low tide that host large congregations of shorebirds and wading birds (including Scarlet Ibis [*Eudocimus ruber*]) and mangroves that support large numbers of nesting and roosting wading birds	
Victoria Seaside	4	Mangrove and brackish marsh	Extensive mangrove and brackish marsh along the shoreline and inland that provides important roosting and breeding site for shorebirds and waterbirds, particularly Scarlet Ibis (*Eudocimus ruber*) and mangrove-dependent species	

Important Bird Habitat	Region	Primary Bird Habitat	Rationale for Designation as Important Bird Habitat	Photograph
Bush Lot Seaside	5	Mudflat and mangrove	Extensive mudflats used by thousands of shorebirds during migration (threshold site for *Calidris* sp.) and waterbirds throughout the year	
Mangroves between Maida and Phillipe	6	Mangrove	Important roosting and breeding area for thousands of colonial waterbirds	

7.3.2.4. Conservation Status of Guyana Coastal Wildlife Species

Of the coastal wildlife species known to occur in coastal Guyana based on historical data and the 2017–2020 survey records, most are currently listed on the IUCN Red List as Least Concern (LC), which means that the population status of the species does not meet the IUCN criteria for a Threatened or Near Threatened designation (IUCN 2021; see Section 7.1.2, Existing Conditions—Protected Areas and Special Status Species). Fourteen of the wildlife species known to occur in coastal Guyana have elevated conservation status, as they are classified as Vulnerable (VU), Near Threatened, (NT), or Endangered (EN) per the IUCN Red List (Table 7.3-6). These species include three mammal species and nine bird species (Figures 7.3-13 and 7.3-14).

In addition, three bird species of local conservation interest[6] have been recorded along the Guyana coast during the EEPGL-commissioned coastal bird surveys between 2017 and 2020. The Silvered Antbird (*Sclateria naevia*) was recorded in the Winter 2019 survey, while the Gray-headed Kite (*Leptodon cayennensis*) and the subspecies *fumosus* of Fuscous Flycatcher (*Cnemotriccus fuscatus*) were observed on the Essequibo Islands during the Fall 2017 survey.

Table 7.3-6: Coastal Wildlife Species with Elevated Conservation Status Known to Occur in Coastal Guyana[7]

Species	Common Name	IUCN Red List Status
Mammals		
Pteronura brasiliensis	Giant otter	EN
Lontra longicaudis	Neotropical otter	NT
Trichechus manatus	American manatee	VU
Sotalia guianensis	Guiana dolphin	NT
Pseudorca crassidens	False killer whale	NT
Birds		
Agamia agami	Agami Heron	VU
Conirostrum bicolor	Bicolored Conebill	NT
Harpia harpyja	Harpy Eagle	NT
Calidris canutus	Red Knot	NT
Calidris pusilla	Semipalmated Sandpiper	NT
Patagioenas subvinacea	Ruddy Pigeon	VU
Buteogallus aequinoctialis	Rufous Crab-hawk	NT
Picumnus spilogaster	White-bellied Piculet	VU
Ramphastos tucanus	Red-billed Toucan	VU

[6] Species of local conservation interest are species that are considered by Guyanese and international bird specialists to be rare and/or declining in Guyana or have very limited distribution in Guyana but are not species of global conservation concern based on their IUCN Red List status.
[7] Excludes marine mammals, marine turtles, and fishes, which are discussed in Sections 7.5, 7.7, and 7.8

Photo Credit: Waldyke Prince

Figure 7.3-13: Rufous Crab-Hawk (*Buteogallus aequinoctialis*), a Non-Migrant Coastal Endemic Species that Occurs in Mangroves and Other Wetland Areas, Observed at Ruimzeight Seaside in 2017

Photo credit: Waldyke Prince

Figure 7.3-14: Bicolored Conebill (*Conirostrum bicolor*), a Coastal Mangrove Specialist, Observed at the Maida Seaside Region 6, January 2019

The primary survey data presented in this section were collected within the 5 years preceding the publication of this EIA, and were generally representative of conditions along Guyana's coastline at the time the EIA was published. Although the distribution of certain kinds of coastal habitats (e.g., mudbanks, mangroves) may change year to year (and the distribution of certain wildlife species may change with them), the general characteristics of Guyana's coastal habitat have remained similar since the information was collected. For these reasons, the Consultants consider the data presented in this section adequate to support an assessment of the Project's likely impacts on coastal wildlife.

7.3.3. Impact Assessment—Coastal Wildlife

The planned Project activities, the bulk of which will occur approximately 203 kilometers (126 miles) northeast of the coastline of Georgetown, will not impact coastal wildlife. The Project will not involve any direct disturbance of coastal wildlife species or their habitats. The shorebases are expected to be located in existing developed areas, so their ongoing use will have little to no impact on coastal wildlife species, other than possible disturbance to common generalist species[8] that are adapted to living in developed areas. The Project's only potential impact on coastal wildlife would be as a result of an unplanned event (i.e., an oil spill), which is discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

7.4. SEABIRDS

7.4.1. Administrative Framework—Seabirds

Table 7.4-1 summarizes the legislation, policies, or treaty commitments that are specifically relevant to the assessment of potential impacts on seabirds.

Table 7.4-1: Legislation, Policies, or Treaty Commitments—Seabirds

Title	Objective	Relevance to the Project
Legislation		
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013; the Wild Birds Protection Act, 1987; and the Species Protection Regulations, 1999)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a framework to address the national goals for wildlife protection, conservation, and management. The Act also provides recommendations on measures for the protection of threatened ecosystems and habitats, and advises on measures for conservation of biological diversity.

[8] Generalist species are species that live in a wide range of habitat types and conditions and that do not have specialized habitat requirements or preferences.

Title	Objective	Relevance to the Project
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity (Guyana signed in 1992 and ratified in 1994)	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Encourages Project design and execution to protect and conserve biological diversity.
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (Guyana acceded and ratified in 2010)	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection of the marine environment, especially from possible pollution.

7.4.2. Existing Conditions—Seabirds

7.4.2.1. Background

Seabirds are birds that spend extensive time in nearshore and/or offshore marine environments away from land, except when they are nesting. Types or groups of seabirds prevalent in this region include frigatebirds, pelicans, petrels, shearwaters, storm-petrels, jaegers, tropicbirds, boobies, gulls, and terns.

Birds in the Stabroek Block typically fit one or more of three characterizations: (1) birds that spend extensive time in waters of the Caribbean away from land or other structures (commonly referred to as pelagic birds or marine birds); (2) birds engaged in seasonal, usually latitudinal, migrations through the area (migratory birds); and (3) birds that have wandered outside their normal ranges, including birds affected by severe weather events, including seasonal storms. The primary focus of this section is on pelagic seabirds since they are the dominant bird type to occur in the Stabroek Block and they spend the most time of any birds offshore Guyana.

Seabirds feed on fish and other marine organisms that concentrate on or near the surface of the water, either by surface feeding (from flight or swimming) or by diving (Hunt and Furness 1996). As such, the presence and availability of seabird prey in a given area, which is strongly influenced by the ocean's currents, is a major determinant in the occurrence of seabirds. Further, water clarity can impact a seabird's foraging success and some studies have suggested that seabirds in the Caribbean prefer areas with clear water where they can more easily see their prey (Schreiber 2001).

Seabirds in the PDA area are likely to be transients, moving opportunistically with schools of fish, oceanic arthropods, plankton, and other prey. The marine environment within the PDA is heavily influenced by the Guiana Current, which is a strong surface current that directs surface flows northwestward, drawing water from near Africa and feeding the Gulf Stream across the northern Caribbean. No slower-moving or circular currents or areas of upwelling that could concentrate marine biota are known to occur in the PDA (see Section 6.4.2.1, Oceanographic Conditions). Further, no islands or near-surface submarine ridges that would be an attractant to foraging seabirds occur in the PDA. While a variety of fish occur in the PDA, including schooling

fish such as tuna and mahi-mahi, and flying fish (Exocoetidae), which are an important prey for both, no evidence suggests that large concentrations of fish consistently occur in the PDA to the extent that they would promote regular use by foraging seabirds. The turbid conditions in the Stabroek Block further reduce the likelihood that the area has significant importance for foraging seabirds.

More than 100 bird species have populations that migrate between North America and South America, and most of these nest in the north and reside in the southern range until the next nesting season. Many of these birds fly over the Caribbean, and in some cases the Stabroek Block, during migration. Although migration routes are well-defined for some bird species, the routes and timing of migration can vary markedly depending on climate and storms (McGrady et al. 2006).

7.4.2.2. Historical Data

Twenty-two species of seabirds are historically known to breed in the Caribbean and dozens more occur as migrants through the region. Seabird data specific to Guyana are extremely limited and no comprehensive survey of seabirds has ever been conducted in Guyana (BirdLife International 2021a). The authoritative, historical list for bird species present in Guyana, published by the Smithsonian Institution, lists 25 seabird species (Braun et al. 2007). BirdLife International lists 22 species of seabirds for Guyana (BirdLife International 2021a. The eBird-arbitrated observation list[9] for offshore Guyana contains 22 seabird species (eBird 2021a. Combining all of these sources, a total of 31 seabird species are reported to occur in Guyana (Table 7.4-2). This list is not specific to the Stabroek Block, but does contain several species that have been documented in the Stabroek Block by EEPGL-commissioned bird surveys (Tables 7.4-3 and 7.4-4).

Table 7.4-2: Seabird Species Known to Occur in Guyana Based on Historical Data

Common Name	Scientific Name
Great Shearwater [a,b]	*Ardenna gravis*
Cory's Shearwater [a,c]	*Calonectris borealis*
Audubon's Shearwater [a,b]	*Puffinus lherminieri*
Wilson's Storm-Petrel [a,b,c]	*Oceanites oceanicus*
Leach's Storm-Petrel [a,b]	*Oceanodrama leucorhoa*
Brown Pelican [a,b,c]	*Pelecanus occidentalis*
Brown Booby [a,b,c]	*Sula leucogaster*
Masked Booby [c]	*Sula dactylatra*
Red-footed Booby [c]	*Sula sula*
Magnificent Frigatebird [a,b,c]	*Fregata magnificens*
White-tailed Tropicbird [c]	*Phaethon lepturus*

[9] eBird is an online database of bird observations through user-submitted checklists. eBird documents the presence or absence of species, as well as bird abundance. Country records in eBird are arbitrated by a team of local experts who are unpaid volunteers managed by eBird. This arbitration process is conducted to ensure data quality and avoid erroneous records. Only the arbitrated country record list is considered scientifically valid.

Common Name	Scientific Name
Red-billed Tropicbird [c]	*Phaethon aethereus*
Parasitic Jaeger [b,c,d]	*Stercorarius parasiticus*
Pomarine Jaeger [a,b,c]	*Stercorarius pomarinus*
Great Skua [a,b]	*Stercorarius skua*
Lesser Black-backed Gull [c,d]	*Larus fuscus*
Laughing Gull [a,b,c]	*Leucophaeus atricilla*
Brown Noddy [a,b,c]	*Anous stolidus*
Black Tern [b,c,d]	*Chlidonias niger*
Gull-billed Tern [a,b,c]	*Gelochelidon nilotica*
Bridled Tern [b]	*Onychoprion anaethetus*
Sooty Tern [a,b]	*Onychoprion fuscatus*
Black Skimmer [a,b,c]	*Rynchops niger*
Roseate Tern [a,c]	*Sterna dougalli*
Common Tern [a,b,c]	*Sterna hirundo*
Royal Tern [a,b,c]	*Thalasseus maximus*
Sandwich Tern [b,c,d]	*Thalasseus sandvicensis*
Least Tern [b,c]	*Sternula antillarum*
Neotropical Cormorant [b]	*Nannopterum brasilianus*
Large-billed Tern [c]	*Phaetusa simplex*
Yellow-billed Tern [c]	*Sternula superciliaris*

[a] Braun et al. 2007
[b] BirdLife International 2021a
[c] eBird 2021a
[d] Sight record only (Braun et al. 2007)

This number is consistent with other countries in the region. For example, 32 and 30 species of seabirds are documented in Trinidad and Tobago and Venezuela, respectively (BirdLife International 2021c and 2021d, respectively). Any of the species could occur in the PDA at some time during the year (specific timing of occurrence is dependent on the species and environmental conditions).

Based on eBird reporting, an additional 29 species of seabirds are known to inhabit the southern Caribbean, but have not been reported in Guyana (eBird 2021a). These species and others could also occur in Guyanese offshore waters. Thus, the number of species that occur offshore Guyana is likely to be higher than 31, as documented through EEPGL-commissioned marine bird survey work conducted in the Stabroek Block between 2017 and 2019 (Section 7.4.2.3, Seabird Survey Data within and near Stabroek Block).

7.4.2.3. Seabird Survey Data within and near Stabroek Block

EEPGL-Commissioned Marine Bird Surveys

Survey Overview

EEPGL commissioned a series of marine bird surveys within the Stabroek Block and in the area between the Stabroek Block and the Guyana coast in 2017, 2018, 2019, and 2020 (see Appendix K, Marine Bird Study Report: Marine Bird Survey 2017–2020). The surveys were conducted by teams of international and Guyanese bird specialists aboard vessels conducting various types of work between the Stabroek Block and Georgetown or within the Stabroek Block. Twelve survey events encompassing 875 survey hours have been conducted to date. Table 7.4-3 summarizes information about each of these surveys and Figure 7.4-1 depicts the locations of the surveys and bird sightings. Of all survey events, the third survey event during the 2018 Fall Survey (Survey 1c) spent the most time in the Stabroek Block; approximately 160 survey hours were conducted in the block during this survey.

Table 7.4-3: Summary of EEPGL-Commissioned Marine Bird Surveys Conducted within the Stabroek Block and between the Stabroek Block and Georgetown, Guyana (2017–2020)

Survey Name	Number of Survey Events per Survey	Survey Date	Survey Area	Mobile or Stationary Survey Vessel [a]	Survey Hours
Fall 2017 Survey	1	30 September 2017–7 October 2017	Between Georgetown and the Stabroek Block	Mobile	46
Spring 2018 Survey	2				
Survey 1a	—	9 April 2018–15 April 2018	Within Stabroek Block	Mobile	60.2
Survey 1b	—	9 April 2018–16 April 2018	Between Georgetown and the Stabroek Block	Mobile	52.8
Fall 2018 Survey	3				
Survey 1a	—	15 September 2018–25 September 2018	Between Georgetown and Stabroek Block, and within Stabroek and Canje Blocks	Mobile	49.5
Survey 1b	—	1 October 2018–6 October 2018	Between Georgetown and Stabroek Block and within Stabroek Block	Mobile	23.5
Survey 1c	—	17 September 2018–1 October 2018	Within Stabroek Block	Stationary	159.8
Winter 2019 Survey	1	28 January 2019–4 February 2019	Within Stabroek Block	Stationary	36.5
Spring 2019 Survey	2				
Survey 1a	—	18 April 2019–23 April 2019	Within Stabroek Block and between Stabroek Block and Guyana coast	Mobile	52
Survey 1b	—	20 April 2019–26 April 2019	Within Stabroek Block and between Stabroek Block and Georgetown	Mobile	29.2
Summer 2019 Survey	1	27 June 2019–17 July 2019	Within Stabroek Block and between Stabroek Block and Georgetown	Mobile	139.5
Fall 2019 Survey	1	17 September 2019–3 October 2019	Within Stabroek Block	Stationary	100.5
Winter 2020 Survey	1	14 February–3 March 2020	Within Stabroek Block and between Stabroek Block and Georgetown	Mobile	125

[a] Refers to whether the survey occurred aboard a stationary or mobile vessel. The stationary vessels were drill ships and the mobile vessels were various types of drill ship support vessels or sampling vessels.

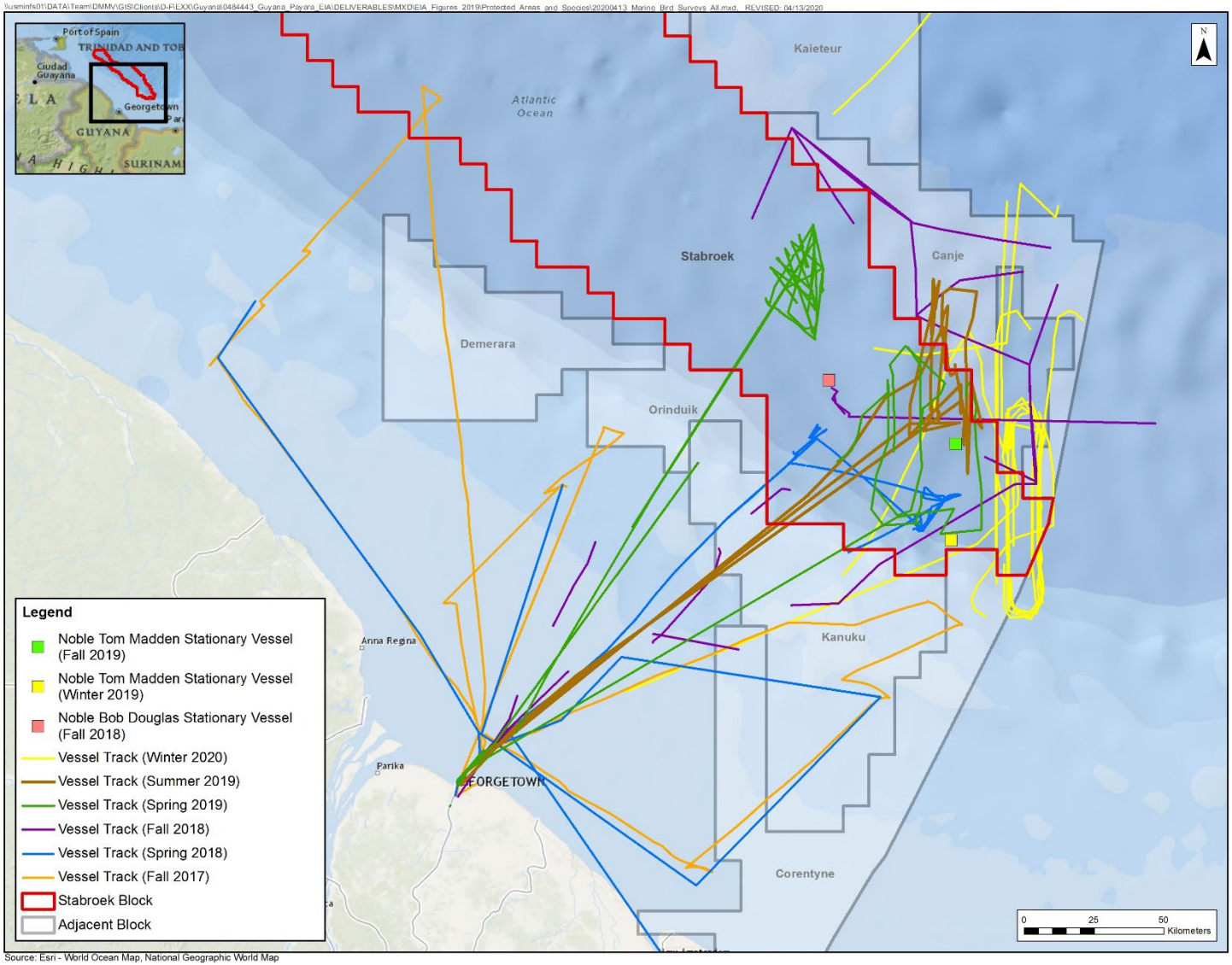


Figure 7.4-1: Map of Marine Bird Survey Locations within the Stabroek Block and between the Stabroek Block and Georgetown, 2017–2020

Species Assemblage

The 12 EEPGL-commissioned marine bird survey events yielded a total of 3,706 bird observations of 53 species offshore Guyana (Table 7.4-4). Fewer than half of the species observed during the surveys are classified as pelagic species[10] (18 of 53 species). The other species are nearshore marine birds undertaking regional (short-distance) movements between breeding and non-breeding areas (14 species), migratory shorebirds (10 species), or landbirds (9 species) that fly over the Caribbean during seasonal (spring and fall) migrations, coastal birds on long-distance offshore foraging trips (1 species), and non-migratory landbirds that were offshore for unknown reasons (1 species) (Table 7.4-5).

Table 7.4-4: Bird Species Observed during EEPGL-Commissioned Marine Bird Surveys Conducted in the Stabroek Block, in Neighboring Blocks, and between the Stabroek Block and Georgetown, 2017–2020[a]

Survey Name	Survey Date	Mobile or Stationary Survey Vessel	Survey Hours	Bird Abundance	Bird Species Richness	Detection Rate (# Observations/ Survey Hour)
Fall 2017 Survey	30 September 2017–7 October 2017	Mobile	46	231	19	5.02
Spring 2018 Survey		Mobile	113	69	14	0.61
Survey 1a	9 April 2018–15 April 2018	Mobile	60.2	29	10	0.48
Survey 1b	9 April 2018–16 April 2018	Mobile	52.8	40	7	0.76
Fall 2018 Survey		Mobile and Stationary	232.8	637	28	2.74
Survey 1a	15 September 2018–25 September 2018	Mobile	49.5	206	20	4.16
Survey 1b	1 October 2018–6 October 2018	Mobile	23.5	314	13	13.36 [b]
Survey 1c	17 September 2018–1 October 2018	Stationary	159.8	117	12	0.73
Winter 2019 Survey	28 January 2019–4 February 2019	Stationary	36.5	58	7	1.59
Spring 2019 Survey		Mobile	81.2	269	21	3.31
Survey 1a	18 April 2019–23 April 2019	Mobile	52	224	18	4.31
Survey 1b	20 April 2019–26 April 2019	Mobile	29.2	45	8	1.54

[10] Includes species that spend their lives at sea except when breeding.

Survey Name	Survey Date	Mobile or Stationary Survey Vessel	Survey Hours	Bird Abundance	Bird Species Richness	Detection Rate (# Observations/ Survey Hour)
Summer 2019 Survey	27 June 2019–17 July 2019	Mobile	139.5	251	10	1.80 [b]
Fall 2019 Survey	17 September 2019–3 October 2019	Stationary	100.5	93	17	0.93
Winter 2020 Survey	14 February–3 March	Mobile	125	2,098	13	16.78
All Surveys Combined	—	—	874.5	3,706	53	4.24

[a] Excludes birds observed within 5 kilometers (3.1 miles) from shore.
[b] Fall 2018 Survey 1b, Summer 2019 Survey, and Winter 2020 detection rates are skewed by large flocks of Common Tern (n= 190), Magnificent Frigatebird (n = 107), and Sooty Tern (n = 1,900) respectively. Corrected detection rates are 1.92 for fall 2018 (5.27 for Survey 1b), 1.0 for summer 2019, and 1.58 for winter 2020.

The EEPGL-commissioned marine bird surveys yielded eight new records for Guyana (based on available documentation, these species had not been observed in the country previously).The new records registered for Guyana are Bridled Tern (*Onychoprion anaethetus*), Manx Shearwater (*Puffinus puffinus*), Red-billed Tropicbird (*Phaethon aethereus)*, White-tailed Tropicbird (*Phaethon lepturus*), Bulwer's Petrel (*Bulweria bulwerii)*, Masked Booby (*Sula dactylatra*), Great Black-backed Gull (*Larus marinus*), and Arctic Tern (*Sterna paradisaea*). Two unconfirmed species, Black-browed Albatross (*Thalassarche melanophrys)* and Northern Gannet (*Morus bassanus)* may be additional new records for Guyana, but these species require field or photographic confirmation before they are added to the definitive species list. Figures 7.4-2 and 7.4-3 provide photographs from the EEPGL-commissioned marine bird surveys of two of the newly documented seabird species in Guyana.

New country record for Guyana; observed within the Stabroek Block, Fall 2018

Figure 7.4-2: Masked Booby (*Sula dactylatra*)

New country record for Guyana; observed in the Stabroek Block, April 2019

Figure 7.4-3: Red-billed Tropicbird (*Phaethon aethereus*)

Table 7.4-5: Bird Species Observed during EEPGL-Commissioned Marine Bird Surveys Conducted in the Stabroek Block and between the Stabroek Block and Georgetown, 2017–2020

Common Name	Scientific Name	Life History Category	2017 Fall	2018 Spring	2018 Fall	2019 Winter	2019 Spring	2019 Summer	2019 Fall	2020 Winter	Total Abundance	Number of Surveys Observed
Arctic Tern	*Sterna paradisea*	Pelagic					1				1	1
Audubon's Shearwater	*Puffinus lherminieri*	Pelagic					5	4			9	2
Brown Booby	*Sula leucogaster*	Pelagic	1	1	4		2	17	8		33	6
Brown Noddy	*Anous stolidus*	Pelagic	2		2	1				2	7	4
Bulwer's Petrel	*Bulweria bulwerii*	Pelagic		1	4						5	2
Cory's Shearwater	*Calonectris diomedea*	Pelagic					1			4	5	2
Great Shearwater	*Ardenna gravis*	Pelagic			1		1	1			3	3
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	Pelagic		17			23			11	51	3
Manx Shearwater	*Puffinus puffinus*	Pelagic					1				1	1
Masked Booby	*Sula dactylatra*	Pelagic		3	37	21	66	22	20	114	283	7
Parasitic Jaeger	*Stercorarius parasiticus*	Pelagic		2			3			4	9	3
Pomarine Jaeger	*Stercorarius pomarinus*	Pelagic	2	4		5	3		1	4	19	6
Red-billed Tropicbird	*Phaethon aethereus*	Pelagic		2			6			8	16	3
Red-footed Booby	*Sula sula*	Pelagic	1	2	2	2			2	1	10	6
Sooty Shearwater	*Ardenna grisea*	Pelagic				2					2	1

Common Name	Scientific Name	Life History Category	2017 Fall	2018 Spring	2018 Fall	2019 Winter	2019 Spring	2019 Summer	2019 Fall	2020 Winter	Total Abundance	Number of Surveys Observed
Sooty Tern	*Onychoprion fuscatus*	Pelagic					43			1,941	1,984	2
White-tailed Tropicbird	*Phaethon lepturus*	Pelagic					2			1	3	2
Wilson's Storm-Petrel	*Oceanites oceanicus*	Pelagic		5			68				73	2
Great Black-backed Gull	*Larus marinus*	Nearshore Marine				1					1	1
Lesser Black-backed Gull	*Larus fuscus*	Nearshore Marine								1	1	1
Black Skimmer	*Rynchops niger*	Nearshore Marine	1				12				13	2
Black Tern	*Chlidonias niger*	Nearshore Marine			46						46	1
Bridled Tern	*Onychoprion anaethetus*	Nearshore Marine	13		2						15	2
Brown Pelican	*Pelecanus occidentalis*	Nearshore Marine	1		2			7			10	3
Cayenne Tern	*Thalasseus eurygnatha*	Nearshore Marine	10								10	1
Common Tern	*Sterna hirundo*	Nearshore Marine	28	9	190		9	14	8		258	6
Laughing Gull	*Leucophaeus atricilla*	Nearshore Marine	19	11	102		3	5	1		141	6
Least Tern	*Sternula antillarum*	Nearshore Marine			11						11	1
Magnificent Frigatebird	*Fregata magnificens*	Nearshore Marine	136	8	65	26	12	177	3	4	431	8
Roseate Tern	*Sterna dougalli*	Nearshore Marine			2						2	1
Royal Tern	*Thalasseus maximus*	Nearshore Marine	3	3	6		2	3			17	5

Common Name	Scientific Name	Life History Category	2017 Fall	2018 Spring	2018 Fall	2019 Winter	2019 Spring	2019 Summer	2019 Fall	2020 Winter	Total Abundance	Number of Surveys Observed
Sandwich Tern	*Thalasseus sandvicensis*	Nearshore Marine	1		8						9	2
Little Blue Heron	*Egretta caerulea*	Coastal	5		5			1			11	3
American Golden Plover	*Pluvialis dominica*	Shorebird							1		1	1
Black-bellied Plover	*Pluvialis squatarola*	Shorebird			25						25	1
Least Sandpiper	*Calidris minutilla*	Shorebird			2						2	1
Lesser Yellowlegs	*Tringa flavipes*	Shorebird			5				2		7	2
Pectoral Sandpiper	*Calidris melanotos*	Shorebird	1								1	1
Ruddy Turnstone	*Arenaria interpres*	Shorebird		1	4						5	2
Semipalmated Plover	*Charadrius semipalmatus*	Shorebird					1		1		2	2
Semipalmated Sandpiper	*Calidris pusilla*	Shorebird	1		16						17	2
Spotted Sandpiper	*Actitis macularius*	Shorebird	1						1		2	2
Whimbrel	*Numenius phaeopus*	Shorebird	1				5				6	2
Cliff Swallow	*Petrochelidon pyrrhonota*	Migratory Landbird			8				2		10	2
Bank Swallow	*Riparia riparia*	Migratory Landbird			1						1	1
Barn Swallow	*Hirundo rustica*	Migratory Landbird	4		84				39	3	130	4

Common Name	Scientific Name	Life History Category	2017 Fall	2018 Spring	2018 Fall	2019 Winter	2019 Spring	2019 Summer	2019 Fall	2020 Winter	Total Abundance	Number of Surveys Observed
Black-whiskered Vireo	*Vireo altiloquus*	Migratory Landbird							1		1	1
Bobolink	*Dolichonyx oryzivorus*	Migratory Landbird			1						1	1
Eastern Kingbird	*Tyrannus tyrannus*	Migratory Landbird							1		1	1
Purple Martin	*Progne subis*	Migratory Landbird			1						1	1
Yellow Warbler	*Setophaga petechia*	Migratory Landbird							1		1	1
Yellow-billed Cuckoo	*Coccyzus americanus*	Migratory Landbird							1		1	1
Eurasian Collared-Dove	*Streptopelia decaocto*	Non-migratory Landbird			1						1	1
Total Abundance			**231**	**69**	**637**	**58**	**269**	**251**	**93**	**2,098**	**3,706**	
Total Species Richness			**19**	**14**	**28**	**7**	**21**	**10**	**17**	**13**	**53**	

Bird Abundance

The data collected during the EEPGL-commissioned marine bird surveys indicate that seabird abundance offshore is generally low and decreases with greater distance to shore. The bird detection rate across all surveys ranged widely from 0.48 to 16.8 birds per hour of observation, with a mean detection rate of 4.24 birds per hour of observation (Table 7.4-4). Bird abundance was generally highest in the area between 1 and 25 kilometers (0.62 and 15.5 miles) from shore and steadily decreased with increased distance to shore, with the fewest number of birds in areas more than 100 kilometers (62 miles) from shore (with the exception of the Winter 2020 survey, discussed below).

For all surveys conducted to date, the greatest abundance of birds was generally observed during the fall and spring surveys (Figure 7.4-4). The Fall 2017, Fall 2018 Survey 1b, Spring 2019 Survey 1a, and Winter 2020 events had the greatest abundance per survey effort (5.0, 13.4, 4.3, and 16.8 birds per hour, respectively, see Figure 7.4-4), but the Winter 2020 results were skewed by multiple detections of large flocks of Sooty Terns (*Onychoprion fuscatus*) (five observations totaling approximately 1,900 birds). Without the five large flocks of Sooty Terns, the Winter 2020 detection rate was 1.6 birds per survey hour, which is lower than both the Fall 2017 and Fall 2018 Survey 1b detection rates and comparable to the Winter 2019 detection rate (also 1.6 birds per survey hour).

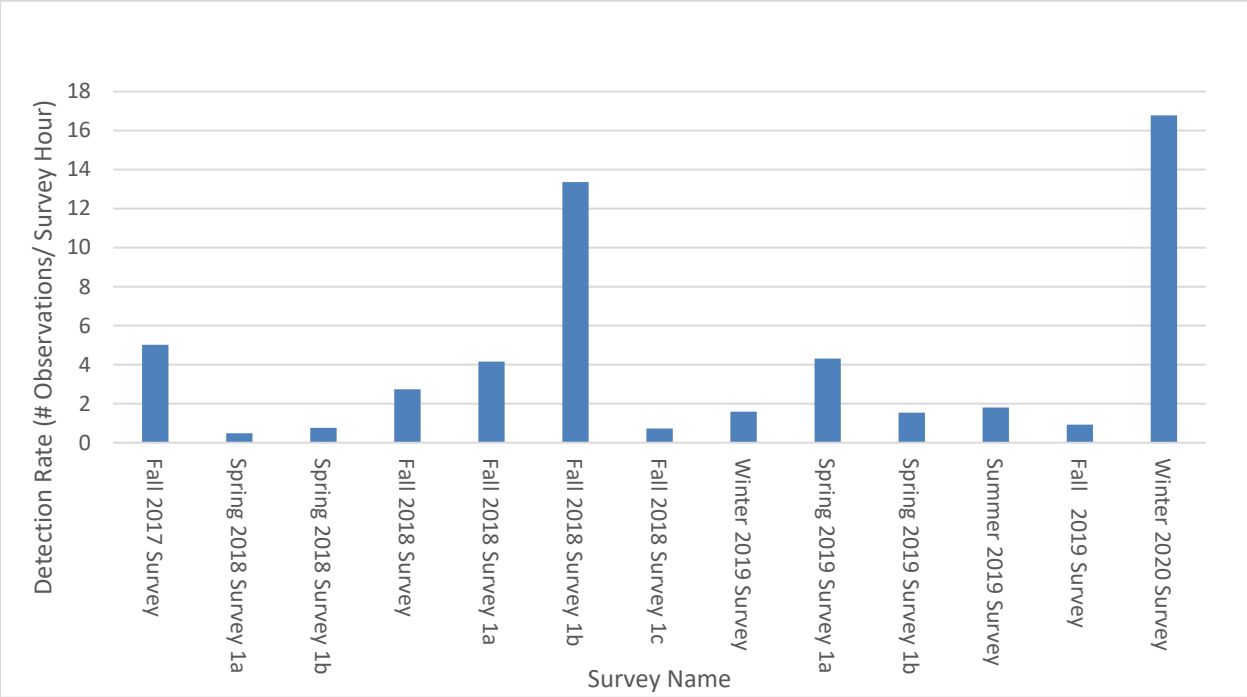


Figure 7.4-4: Overall Bird Abundance Documented per Survey Event during EEPGL-Commissioned Marine Bird Surveys, 2017–2020 (All Surveys)

The relatively high bird abundance observed during the Fall 2017 and Fall 2018 survey events is mostly attributable to the number of migrating shorebirds and landbirds moving through the area during those periods (Table 7.4-4). The spring surveys conducted in 2018 and 2019 also documented higher bird abundance than the Winter 2019 survey (neglecting the skewed results from the Winter 2020 survey), and the species assemblage during the Spring 2018 and 2019 surveys also included numerous migratory birds.

For all survey events combined, the most commonly observed bird species in and near the Stabroek Block were the Sooty Tern, Magnificent Frigatebird (*Fregata magnificens*), Masked Booby, Common Tern (*Sterna hirundo*), and Laughing Gull (*Leucophaeus atricilla*). Figure 7.4-5 depicts the total abundance (all surveys combined) for the dominant species observed (species with at least 10 observations during the EEPGL-commissioned survey events.

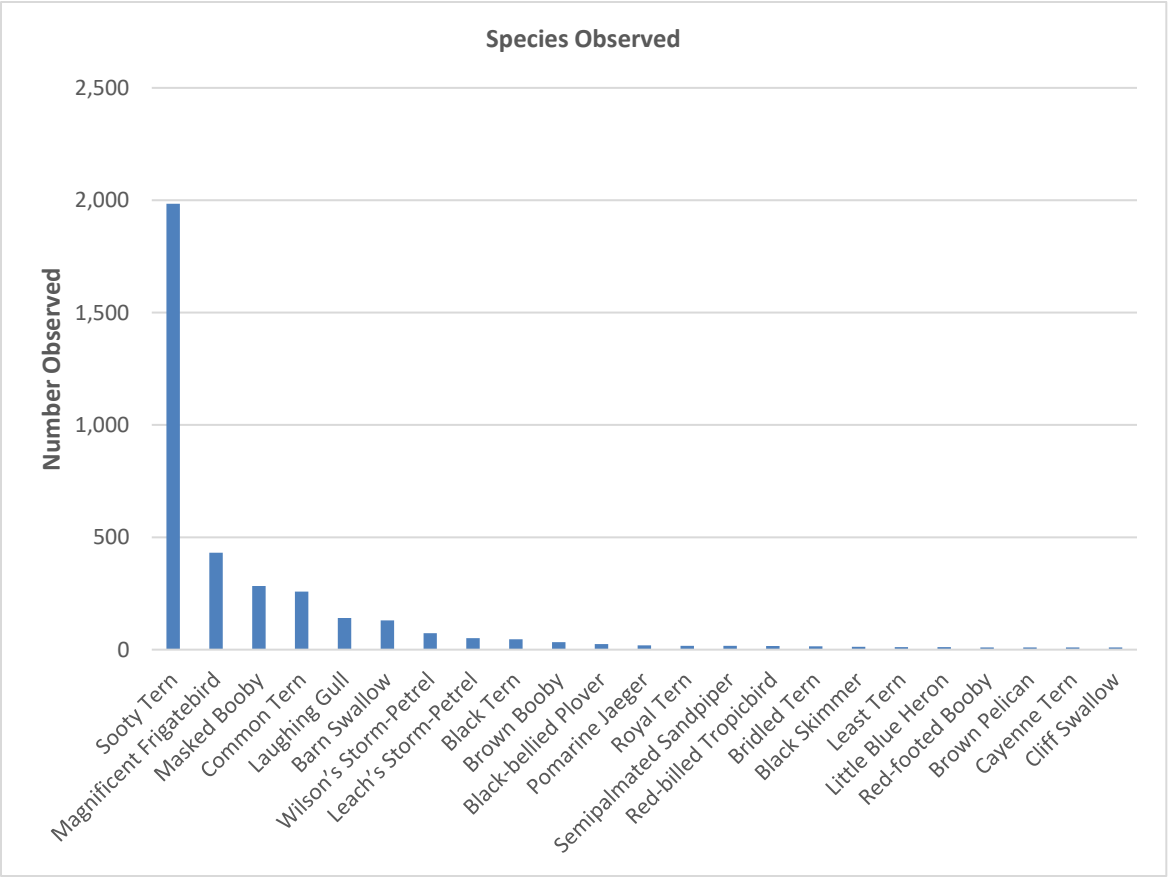


Figure 7.4-5: Most Frequently Observed Bird Species during the EEPGL-commissioned Marine Bird Surveys, 2017–2020 (All Surveys)

Species Richness and Diversity

As recorded during the EEPGL-commissioned marine bird surveys, the number of bird species (described as species richness) and the diversity of bird species encompassing a broad range of bird types (i.e., landbirds, coastal birds, shorebirds, and pelagic and nearshore birds that collectively are considered seabirds) (see Figure 7.4-6), were higher than expected based on

historical records for the region and expert knowledge. The surveys showed a clear differentiation in the species assemblage (types of birds) observed by season: nearshore marine birds were the dominant type during the Fall 2017 and Fall 2018 surveys, and pelagic birds heavily dominated the Spring 2019 survey. The Summer 2019 and Winter 2019 surveys were the only surveys conducted to date to have only nearshore marine and pelagic birds observed (Figure 7.4-6).

Bird species richness varied across the various survey periods (Table 7.4-4 and Figure 7.4-7). With the exception of the Fall 2019 survey, all spring and fall surveys had higher species richness than the winter and summer surveys (Figure 7.4-7) due to the presence of migratory species in spring and fall. Fall 2018 had the highest species richness of any survey period). The Fall 2018 Survey recorded many migratory coastal and landbird species, documenting use of the area by latitudinal migrants. All spring and fall surveys across the study period had higher species richness than the winter and summer surveys (Figure 7.4-7) due to the presence of migratory species in spring and fall. Winter 2019 had the lowest species richness, but also had among the lowest number of survey hours.

The differences seen across survey periods are typical of seasonal patterns—with higher richness and abundance during migration periods—as well as some random variation between periods. The following are key seasonal differences:

- The fall surveys had a preponderance of migratory swallow and migratory shorebird species (e.g., sandpipers, plovers, etc.).
- A substantial number of the pelagic birds sighted during the spring surveys in 2018 and 2019 were Leach's Storm-Petrels (*Oceanodroma leucorhoa*).
- Winter and summer surveys had lower abundance, and the species assemblage was heavily dominated by pelagic and nearshore marine species (Figures 7.4-6 and 7.4-7).

Shorebirds and migratory landbirds were almost exclusively observed during spring and fall (migratory) periods (Figure 7.4-6). The seasonal variations described above indicate that the Stabroek Block and surrounding offshore area serve as habitat for seabirds undergoing multiple types of trans-continental migrations: classic Nearctic-Neotropic migration (jaegers and Common Tern); transoceanic migration (Bulwer's Petrel, Band-rumped Storm-Petrel, Leach's Storm-Petrel); and austral migration (shearwaters, Wilson's Storm-Petrel [*Oceanites oceanicus*]). Many of the species observed during the Spring 2018 and Spring 2019 surveys were northern breeders that had not yet departed for the breeding grounds or were passing through the region on their way northward, which indicates that Guyana's offshore marine ecosystem may be an important staging area[11] for seabirds breeding in both the northern and southern hemispheres.

[11] Staging areas are areas along bird migration corridors that are consistently used by migrating birds for foraging and resting.

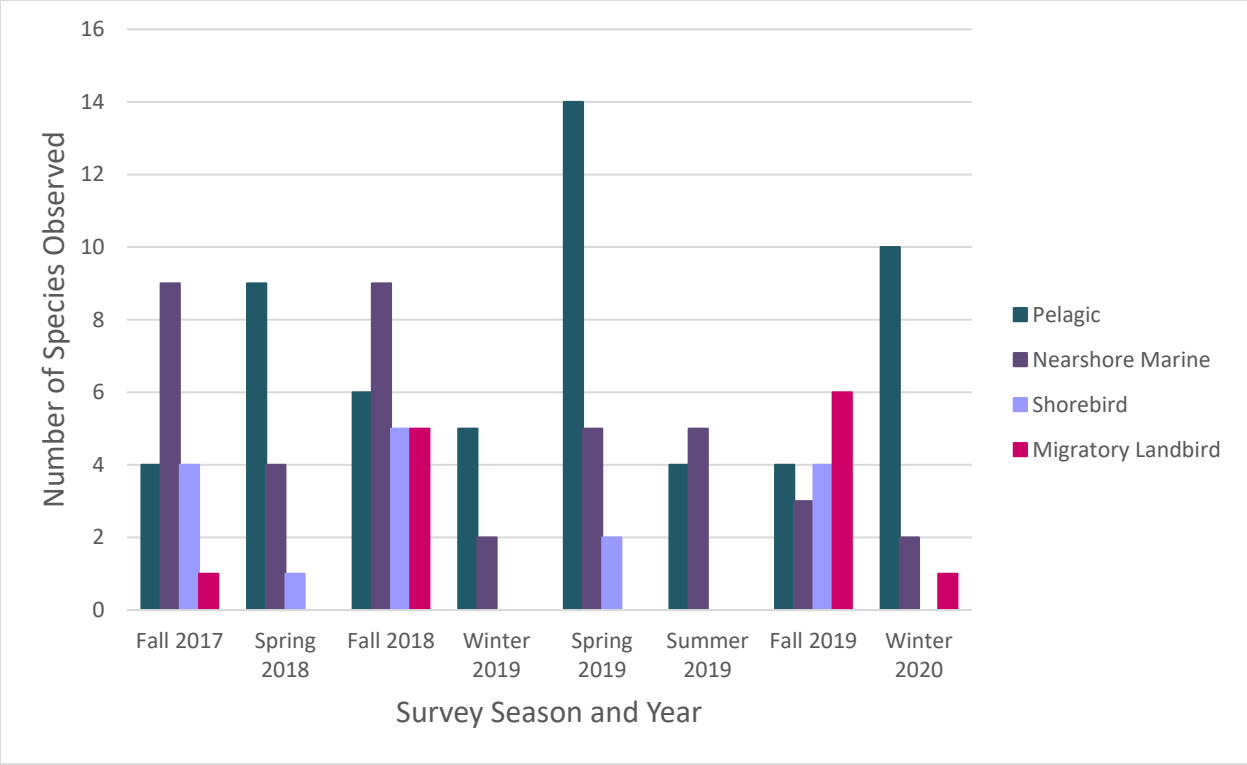


Figure 7.4-6: Bird Species Assemblage (Life History Categories) Recorded during Five Seasons of EEPGL-Commissioned Marine Bird Surveys

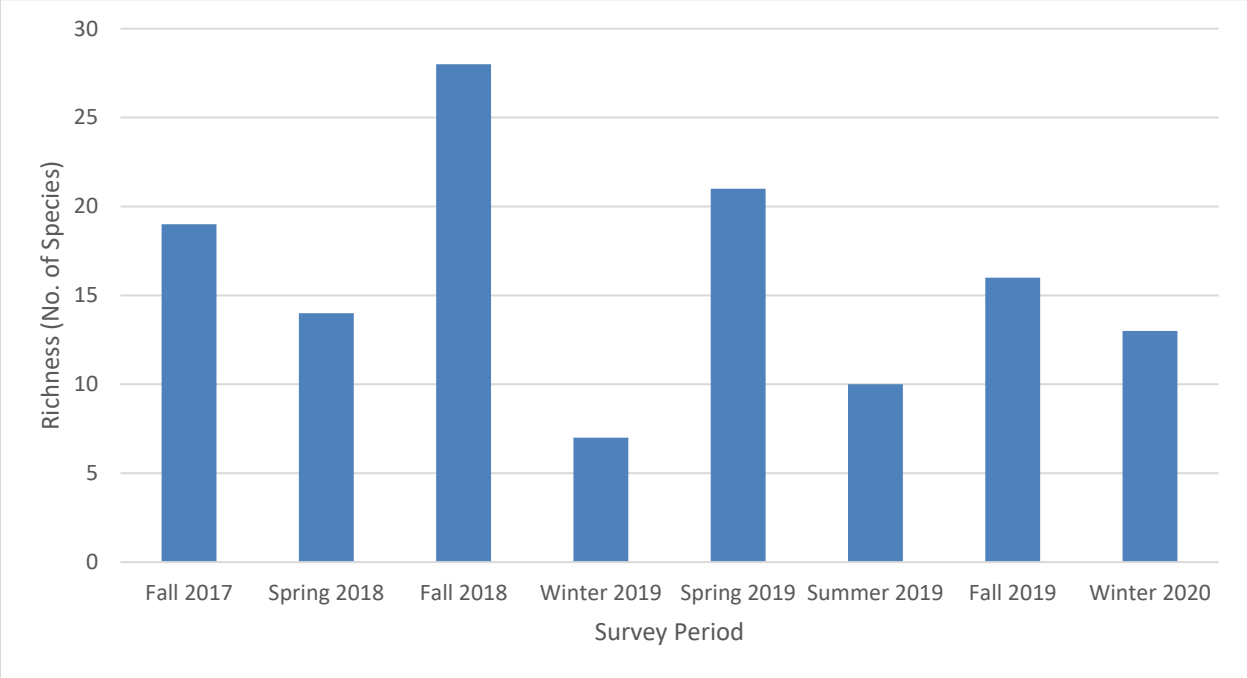


Figure 7.4-7: Seasonal Bird Species Richness Documented during EEPGL-Commissioned Marine Bird Surveys

In addition to the trans-continental migrations described above, the marine bird survey data indicate that the Stabroek Block and the surrounding offshore area are used by a variety of nonmigratory seabirds for regional dispersal (movements between non-breeding and breeding sites). The use of the area for seasonal movements to breeding sites such as the nearby IBAs in Tobago and St. Vincent and the Grenadines (see Section 7.4.2.5, Important Bird Areas for Seabirds near Stabroek Block) is demonstrated by the sightings of Red-billed Tropicbird, Magnificent Frigatebird, and multiple booby species in breeding plumage flying in a northwesterly direction towards Tobago and St. Vincent and the Grenadines. All of these species are known to nest in the Tobago and St. Vincent and the Grenadines IBAs.

Incidental Seabird Observations Within and Near the Stabroek Block

Incidental observations within and en route to the Stabroek Block have been recorded by Protected Species Observers (PSOs) during various EEPGL-commissioned environmental and geophysical sampling and survey activities offshore Guyana from 2015 through 2021 (RPS 2018; RPS 2019; RPS 2020a,b,c,d,e; RPS 2021). To date, PSOs have documented 7,566 individual birds representing 70 bird species offshore and nearshore Guyana during 1,891 survey days from May 2015 through May 2021 (RPS 2018; RPS 2019; RPS 2020a,b,c,d,e; RPS 2021). Of these 70 species, 43 were also observed during the targeted EEPGL-commissioned marine bird surveys described above and 27 species were not documented during the targeted EEPGL-commissioned marine bird surveys. Of the 27 species not observed, four are pelagic seabirds and 23 are landbirds or coastal birds. The four pelagic seabird species recorded by PSOs, but not documented during EEPGL's targeted marine bird surveys, include Black-capped Petrel (*Pterodroma hasitata*), Great Skua, South Polar Skua (*Stercorarius maccormicki*), and Northern Gannet[12]. Of these five species, two (South Polar Skua and Northern Gannet) would be new country records for Guyana if confirmed with photographic evidence.

Similar to that documented in the EEPGL-commissioned marine bird surveys, the most common identified species documented through the incidental observations were Masked Booby, Magnificent Frigatebird, Barn Swallow (*Hirundo rustica*), and Brown Booby (*Sula leucogaster*).

Summary of Available Seabird Data for the Stabroek Block

The following points can be drawn from the EEPGL-commissioned marine bird surveys and incidental bird data collected during other offshore survey missions:

1. The data indicate that the seasonal differences in bird community composition are driven by the occurrence of migratory species that breed in fall and spring at both northern and southern latitudes, and move offshore and to the tropics during their non-breeding seasons. As a result, avifauna changes substantially and consistently across a broad geographic area over the course of each year.

[12] The Northern Gannet was provisionally identified during the EEPGL-commissioned marine bird surveys but the observations were not confirmed by photographic identification. As such, these are considered provisional records and are not included in the confirmed species list for the EEPGL-commissioned marine bird surveys or the related data analysis.

2. A wide complement of seabirds (including 19 pelagic and 13 nearshore marine species), including at least one species of global conservation importance (Leach's Storm-Petrel), occur in the Stabroek Block and surrounding waters. Another species of global conservation importance, Black-capped Petrel, has been documented in and around the Stabroek Block during other surveys[13] but this species was not documented during the EEPGL-commissioned studies.
3. Seasonal, latitudinal migration of seabirds, shorebirds, and landbirds occurs in the Stabroek Block and surrounding waters. Spring and fall surveys recorded numerous species of migratory shorebirds and landbirds from North America, confirming that at least some individuals of these species arrive in Guyana over water rather than by following the continental coastline. Seabird abundance is generally low far offshore but increases with proximity to shoreline, and many seabirds, such as terns and gulls, specialize in the nearshore environment instead of far offshore.
4. Many of the species observed during the Spring 2018 Survey and Spring 2019 Survey were northern breeders that had not yet departed for the breeding grounds (or were passing through, e.g., Arctic Tern, suggesting that Guyana's offshore marine ecosystem may be an important staging area[14] for seabirds breeding in the northern hemisphere.
5. During both the Spring 2018 Survey and Spring 2019 Survey, the bird species composition documented within and near the Stabroek Block was dominated by storm-petrels of at least two species—Wilson's Storm-Petrel, an abundant seabird that breeds in the far southern Atlantic, and Leach's Storm-Petrel (Figure 7.4-8), which breeds in New England and maritime Canada and is listed as Vulnerable by the IUCN (IUCN 2021). Neither of these species was observed during the Fall 2017, Fall 2018, or Fall 2019 Surveys, indicating that their use of offshore Guyana waters is strictly seasonal (spring). Leach's Storm-Petrels were also observed in the Winter 2020 Survey, but this survey was conducted in late winter, so the 11 individuals of this species that were observed during that survey likely represented the leading edge of the spring 2020 migration. The presence of Wilson's Storm-Petrel and Leach's Storm-Petrel in substantial numbers during the spring surveys in 2018 and 2019 highlights the importance of this area as a regular migration waypoint for these species from both northern and southern hemispheres. Both of these species appear to be more common off Guyana than Suriname or French Guiana.

[13] Black-capped Petrel was not observed during EEPGL-commissioned marine bird surveys. This species was recorded on multiple occasions by PSOs while conducting other work in the Stabroek Block during the time period from 2015 to 2019. Discussions with species experts indicate that the species likely occurs as a rare transient offshore Guyana.

[14] Staging areas are areas along bird migration corridors that are consistently used by migrating birds for foraging and resting.

IUCN-listed as Vulnerable; observed in the Stabroek Block, April 2018

Figure 7.4-8: Leach's Storm-Petrel (*Oceanodroma leucorhoa*)

7.4.2.4. Conservation Status of Seabirds Confirmed for Offshore Guyana

Of the 39 species of seabirds known to occur in Guyana based on historical and EEPGL-commissioned survey records, 35 are currently listed on the IUCN Red List as Least Concern, which means that the population status of the species does not meet the IUCN criteria for a Threatened or Near Threatened designation (IUCN 2021) (see Section 7.1.2, Existing Conditions—Protected Areas and Special Status Species). Of the remaining seabird species, one is classified as Vulnerable (Leach's Storm-Petrel), two are classified as Near Threatened (Red Knot and Semipalmated Sandpiper), and one is classified as Endangered (Black-capped Petrel).

Leach's Storm-Petrel was the most common species observed during the Spring 2018 EEPGL-commissioned marine bird surveys within the Stabroek Block, the second-most common species observed during the Spring 2019 marine bird surveys, and eighth-most common species observed across all the EEPGL-commissioned marine bird surveys. In addition, this species was previously reported in Guyana in eBird and during prior EEPGL surveys in the Stabroek Block (RPS 2018; RPS 2019). It nests in cold, northern ocean waters, so these individuals were likely undergoing their seasonal migration when observed in the Stabroek Block. Based on the number of sightings during the Spring 2018, Spring 2019, and Winter 2020 surveys, the Stabroek Block can be considered to contain an appreciable population of this species seasonally.

The Black-capped Petrel, classified by IUCN as Endangered, has been reported in eBird for offshore Guyana and has been recorded during incidental observations collected by PSOs during various sampling activities in and near the Stabroek Block, but has not yet been observed by bird experts or confirmed through photographic documentation during EEPGL-commissioned marine bird surveys, which constitute the only targeted survey of seabirds ever conducted in the region.

The Black-capped Petrel nests in holes on escarpments in the highlands of Haiti and the Dominican Republic, and possibly Cuba, where between 500 and 2,000 nesting pairs occur (Jodice et al. 2015; Simons et al. 2013). Historical nesting areas in Guadeloupe, Martinique, and Dominica are considered to no longer be utilized. Birds nest from January through June, during which adults may make extended foraging trips at sea (Simons et al. 2013). Foraging expeditions of several days and up to thousands of kilometers have been demonstrated by satellite tagging of three nesting adults, which roamed the southern Caribbean in offshore Venezuela, near the Stabroek Block (Jodice et al. 2015). Visual sightings of adults in 2018 have occurred throughout the Caribbean in the waters of Puerto Rico, Dominica, Aruba, and Martinique. Migration occurs after breeding, principally along the Gulfstream along the eastern U.S. shore (eBird 2021b). This species is expected to be a rare transient offshore Guyana.

The Black-capped Petrel tends to feed on vertically migrating nekton[15] (Simons et al. 2013), of which myctophids (lanternfishes, a group of fish species that exhibit bioluminescence) are common to abundant in the waters of the Stabroek Block. The vertical migration of this prey resource at night may make the activity of this bird greater in hours of limited light and night, which could explain why the species was not observed during any of the EEPGL-commissioned marine bird surveys conducted to date - since surveys were not conducted during periods of low light. Other food items include sargassum (a genus of macroalgae), crustaceans, squid, and fish (Simons et al. 2013).

7.4.2.5. Important Bird Areas for Seabirds near Stabroek Block

Since 2010, BirdLife International has focused its efforts on identifying Marine IBAs with specific significance to seabirds. The types of sites that qualify as Marine IBAs include seabird breeding colonies, foraging areas around breeding colonies, non-breeding (usually coastal) concentrations, migratory bottlenecks, and feeding areas for pelagic species (BirdLife International 2021b). No Marine IBAs have been identified in Guyana, but five Marine IBAs of global or regional importance to seabirds have been designated in neighboring and nearby countries that have reasonable potential, based on documented species life histories and foraging distances, to support seabirds that transit the Stabroek Block during local and regional movements to and from their breeding sites or during offshore foraging trips (Table 7.4-6). Figure 7.4-9 depicts one of the seabird species documented during surveys in the Stabroek Block that breeds in these IBAs. Figure 7.4-10 depicts the location of these IBAs relative to the Stabroek Block.

[15] Actively swimming aquatic organisms in a body of water that can move independently from water currents

Table 7.4-6: Marine IBAs with Importance to Seabirds that Transit the Stabroek Block

Important Bird Area Name	Country	IBA Attributes [a]
Little Tobago Island	Trinidad and Tobago	This IBA supports globally important breeding populations of Red-billed Tropicbird (*Phaethon aethereus*) and Laughing Gull (*Leucophaeus atricilla*), and regionally important breeding populations of Audubon's Shearwater (*Puffinus lherminieri*), Brown Booby (*Sula leucogaster*), Red-footed Booby (*Sula sula*), and Bridled Tern (*Onychoprion anaethetus*). Seabird population estimated at over 2,000 breeding pairs.
St. Giles Islands	Trinidad and Tobago	This IBA supports globally important breeding populations of Red-billed Tropicbird and regionally important breeding populations of Audubon's Shearwater, Magnificent Frigatebird (*Fregata magnificens*), Masked Booby (*Sula dactylatra*), and Red-footed Booby. Other seabird species including Brown Booby and Brown Noddy (*Anous stolidus*) also breed there. Total seabird population estimated at over 2,000 individuals.
All Awash Island	St. Vincent and the Grenadines	This IBA supports regionally significant breeding populations of several seabird species, most notably a large breeding population of Roseate Tern (*Sterna dougalli*) (~475 pairs). During the non-nesting period, hundreds to thousands of seabirds forage in surrounding waters and use the island for roosting.
Battowia Island	St. Vincent and the Grenadines	This IBA supports regionally significant populations of roosting and breeding seabirds (>5,000 pairs), including Magnificent Frigatebird, Red-footed Booby, Brown Booby, and Laughing Gull.
Petit Canouan Island	St. Vincent and the Grenadines	This IBA supports regionally significant populations of breeding seabirds (>2,200 pairs) including Sooty Tern (*Onychoprion fuscatus*), Brown Booby, Laughing Gull, Magnificent Frigatebird, Roseate Tern, Royal Tern (*Sterna maxima*), and Brown Noddy.

[a] Sources: BirdLife International 2021a, 2021b

One of the species with large breeding colonies in the Tobago and St. Vincent and the Grenadines IBA; observed in the Stabroek Block, January 2019

Figure 7.4-9: Brown Noddy (*Anous stolidus*)

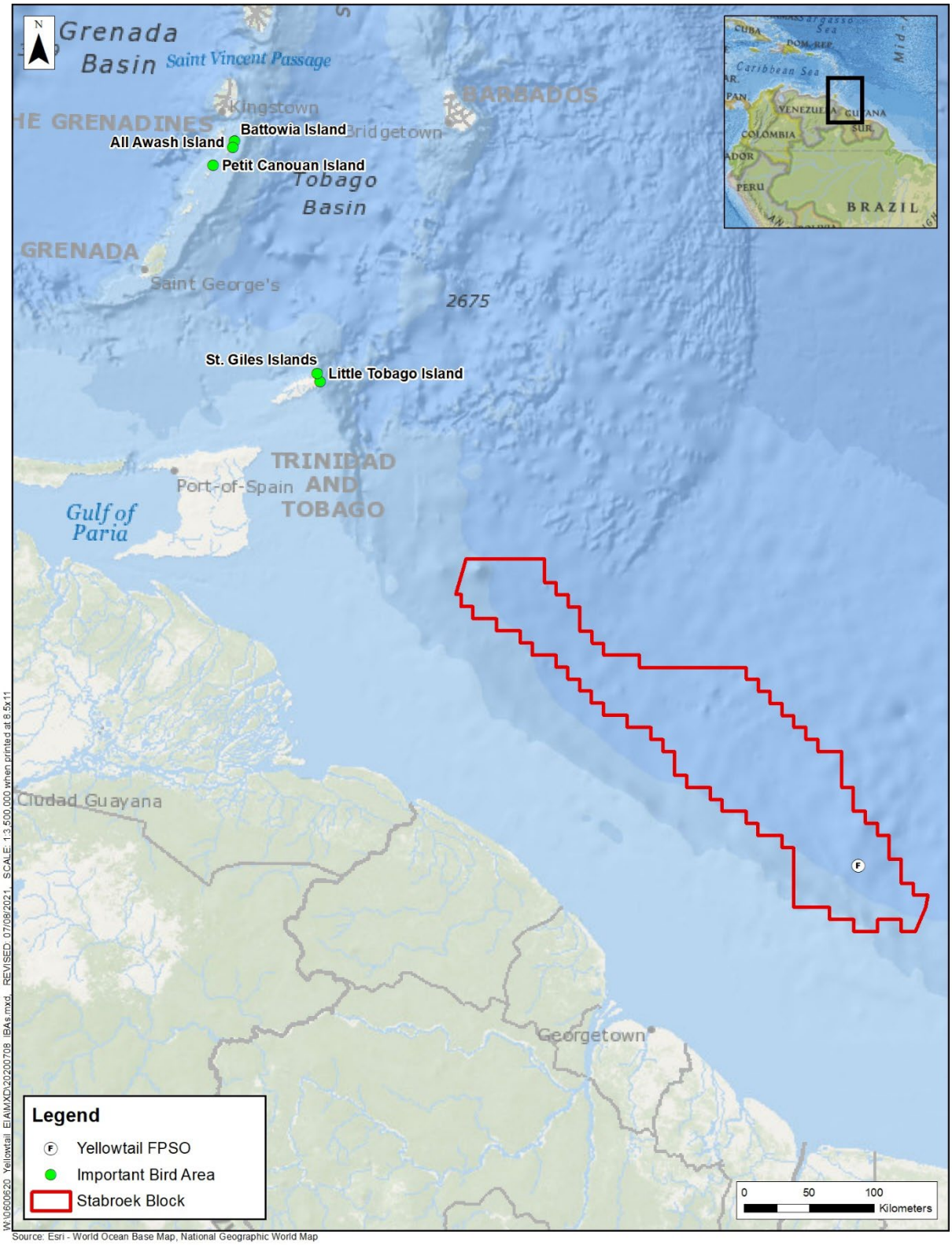


Figure 7.4-10: Location of Marine IBAs with Importance to Seabirds that Transit the Stabroek Block

The information presented in this section was accumulated from a combination of literature sources and field surveys in and around the AOI over the 5 years preceding the publication date of this EIA. The field surveys were conducted during different seasons under a variety of sea states and documented a range of common and uncommon species. Therefore, the Consultants consider the information presented in this section adequate to support an assessment of likely Project impacts on seabirds.

7.4.3. Impact Assessment—Seabirds

This section discusses potential impacts on seabirds from planned Project activities. Thirty-nine seabird species have been documented in Guyana's offshore waters, including the area in the vicinity of the PDA, based on historical and recent survey data. Several resident seabird species occur in the area throughout the year and migratory seabirds typically occur in the area starting in late summer, with many remaining through winter and into early spring. When seabirds are not breeding, they primarily live in offshore environments, moving with prey resources and roosting and loafing on islands or artificial structures in the ocean or simply rafting[16] on the ocean surface. The presence of seabirds in a given area is heavily resource-driven, with individuals and groups of seabirds primarily attracted to prey concentrations. No evidence suggests that large concentrations of seabird prey (primarily fish) consistently occur in the PDA that would promote regular use of the PDA by foraging seabirds. Rather, seabirds in the area are likely transients, moving opportunistically with schools of fish and other prey. The turbid conditions in the PDA further reduce the likelihood that the area has significant importance for foraging seabirds. Further, no islands or artificial structures occur in the PDA, so the area does not contain any known roosting or loafing areas where large numbers of seabirds might congregate. As such and as described above, it is expected that seabirds occur in the PDA throughout the year, but at a relatively low density and for short (transient) periods depending on prey availability. The highest abundance of seabirds offshore Guyana occurs during spring and fall migration.

7.4.3.1. Relevant Project Activities and Potential Impacts

The Project has the potential to impact seabirds through injury (e.g., collision with Project features), disturbance leading to changes in behavior (e.g., via displacement or attraction from sound, lighting, and/or presence of the FPSO), or toxicological effects (e.g., as a result of exposures to Project vessel discharges).

Table 7.4-7 summarizes the Project stages and activities that could result in potential Project impacts on seabirds. Potential impacts on seabirds from unplanned events, including oil spills, contact with the FPSO flare (or heat plume), and vessel and helicopter strikes, are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

[16] Rafting is a common seabird behavior involving a tight aggregation of seabirds floating on the ocean surface to form a "raft."

Table 7.4-7: Summary of Relevant Project Activities and Key Potential Impacts—Seabirds

Stage	Project Activity	Key Potential Impact
Development Well Drilling Subsea, Umbilicals, Risers, and Flowlines / FPSO Installation	Presence of drill ships and installation vessels	• Physical presence of drill ships and installation vessels (with lighting), potentially acting as an attractant to seabirds, exposing them to collision risks, additional energy expenditure, and compromised navigation for night-migrating birds • Vessels may be of benefit to some species that use the vessel for rest or shelter during long flights or adverse weather
	Operation of supply and support vessels	• Light and sound disturbance, leading to attraction to or avoidance of the exposed area
	Discharge of drill cuttings	• Exposures to permitted discharges, potentially leading to toxicological impacts
	Discharge of effluents	
Production Operations	Presence of FPSO	• Physical presence of FPSO (with lighting), potentially acting as an attractant to seabirds, exposing them to collision risks, additional energy expenditure, and compromised navigation for night-migrating birds • Structures may be of benefit to some species that use the structure for rest or shelter during long flights or adverse weather, or as an attractant for seabird prey
	Discharge of cooling water and produced water	• Exposures to permitted discharges, potentially leading to toxicological impacts
	Discharge of effluents	
	Operation of supply and support vessels	• Avoidance or attraction due to lighting and activity
Decommissioning	Decommissioning activities PDA and related vessel traffic	• Light and sound disturbance from decommissioning activities, potentially leading to attraction to or avoidance of the PDA • Removal of a resting place and reliable food source if the FPSO acts as an attractant for seabird prey

Potential impacts from seabird exposure to discharge of drill cuttings, produced water, and other effluents are expected to be negligible. The discharges will rapidly mix with ambient seawater, decreasing effluent constituent concentrations significantly within a short distance of the discharge location. The primary pathway for seabird effects from discharges would be ingestion of fish or other marine organisms that were exposed to effluent discharges and uptake of effluent constituents, which might have bioaccumulated in the organisms as a result of such exposure. The likelihood of this pathway resulting in toxicological effects to seabirds is very low because pelagic fish species by their very nature are transient (and thus would be expected to swim in and out of, or only once through, a plume), meaning they would be highly unlikely to be present in an effluent plume for a sufficient length of time to bioaccumulate significant amounts

of constituents. Further, the PDA is not located within a major seabird migratory flyway, nor is it known to support large numbers of seabirds. Therefore, the number of individuals that could be impacted through this pathway is expected to be limited, meaning the Project will not impact any seabird species at the population level. Accordingly, these impacts are not discussed further in this section. Sections 6.3.3, Impact Assessment—Marine Geology and Sediments, and 6.4.3, Impact Assessment—Marine Water Quality, provide further analysis of the impacts of these discharges on marine sediment and water quality, respectively.

Potential benefits from the Project to seabirds include the use of the FPSO, drill ships, and installation vessels for rest or shelter during adverse weather conditions or during long migrations. In addition, if such vessels act as consistent attractants for seabird prey, they could induce the creation of a reliable food resource for seabirds in the PDA (Fabi et al. 2002). While these are not expected to be significant benefits to seabirds at the population level, they are discussed below.

7.4.3.2. Magnitude of Impacts—Seabirds

The assessment of the Project's magnitude of potential impacts on seabirds is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on seabirds is defined according to the definitions provided in Table 7.4-8. The following paragraphs discuss the characteristics of the potential impacts assessed and the resultant magnitude ratings. These are summarized in Table 7.4.9.

Table 7.4-8: Definitions for Intensity Ratings for Potential Impacts on Seabirds

Criterion	Definition
Intensity	Negligible: No discernible change in seabird behavior or presence in the impacted area or very rare instances of injury or mortality.
	Low: Minor behavioral changes in seabirds or occasional injury or mortality of individuals that would not measurably impact habitat use, regional population status, or viability of seabird populations.
	Medium: Regularly observed changes in seabird behavior, injury, and mortality of individuals, but not such that this would affect the long-term viability of regional seabird populations.
	High: Significant changes in seabird behavior or significant mortality that could affect the long-term viability of seabird populations.

Attraction to Project Vessels and the FPSO

Seabirds are known to aggregate around large offshore installations such as drill ships and can be present in above-average numbers due to artificially increased food concentrations, lighting, and attraction to the structure itself for roosting (Wiese et al. 2001). The impacts of attraction and aggregation on seabirds around an offshore facility can be both positive and negative and can vary considerably by species and, more specifically, a species' typical behavior and the type and length of use of the impacted area. The structure may be beneficial to seabirds by providing a resting place or shelter during feeding, migration, or adverse weather in areas where these places would otherwise not be found (Ronconi et al. 2015). The presence of resting areas

along migration routes is even more advantageous for coastal birds or landbirds that are not physiologically capable of resting on the ocean surface. Exhaustion during mid-flight over water is generally lethal for these species (Deppe et al. 2015). For species that migrate to breeding sites, timing is critical so that they arrive en masse and when conditions are conducive to breeding activity. Resting sites allow them to gauge conditions closer to their destinations and avoid arriving at their destination when conditions are unsuitable. Additionally, by refueling during migration, birds can restore body reserves thus increasing the likelihood of reaching the breeding grounds in good condition (Alves 2016).

The potential adverse impacts associated with seabird attraction to offshore facilities primarily relate to lighting. The drill ships, installation vessels, and FPSO will operate 24 hours a day, so at night they will constitute a prominent source of artificial light in an otherwise dark environment (Montevecchi 2006). The amount of light in the PDA will vary during the different stages of the Project. Lights on offshore oil platforms and other installations are known to act as an attractant to seabirds and typical offshore installation lighting extends roughly 3 to 5 kilometers (2 to 3 miles) around the source (Wiese et al. 2001). Poor weather, such as fog, precipitation, and low cloud cover can exacerbate the impact of nocturnal attraction to lights, especially when coincidental with bird migrations (Ronconi et al. 2015).

Lighting on offshore facilities can be disorienting to night-migrating birds, particularly waterfowl, which migrate using stellar cues that can be obscured by lights (Gaston et al. 2013). Birds lose their stellar cues for nocturnal navigation under low cloud ceiling or other adverse weather conditions, and in these circumstances, artificial lights become the strongest cues that birds have for navigation. As a result, they are attracted to the lights and will fly around them for extended periods, a phenomenon referred to in scientific literature as the “trapping effect” or “light circling.” The time individual birds spend circling can range from a few minutes to several hours to days, with an average of around 15 minutes (Marquenie 2007). The consequences of this may be: (1) energy wasted circling the installation, which can be problematic for individual birds undergoing long migrations; (2) collision with the structure or other birds, potentially resulting in mortality or injury—which can in turn cause individual birds to remain on the structure for long periods where there is no drinking water; (3) increased exposure to Project facilities and activities from the attraction to the area and potential exposure to radiant heat from flaring events, which can cause injury or death; and (4) increased risk of predation due to weakness, disorientation, or injury following long periods of circling or collision with a Project structure (Baird 1990; Ronconi et al. 2015; Platteeuw and Henkens 1997; Deda et al. 2007).

The potential thus exists for Project lighting to result in behavioral changes in seabirds or occasional injury or mortality of individuals, particularly during the production operations phase of the Project when the FPSO will be a consistent presence for a prolonged period (approximately 20 years). As an embedded control to manage lighting-related impacts from the Project, lighting on the FPSO and major vessels will be directed, where practicable, to required operational areas rather than at the sea surface or skyward. This will reduce the intensity and locations of lighting to which seabirds may be exposed by the Project. Further, the PDA is not located within a major seabird migratory flyway, nor is it known to support large numbers of seabirds; accordingly, the number of individuals that could be impacted by the potential impacts

described above is expected to be limited, meaning the Project will not impact any seabird species at the population level. As such, based on the impacts described above and the definitions of the intensity ratings presented in Table 7.4-7, the intensity of the potential impacts on seabirds related to attraction to Project vessels and the FPSO is rated as **Low** during the production operations phase and **Negligible** during the drilling and decommissioning phases. Effects would not extend more than a few kilometers from the light source, so the geographic extent of potential impact is the **Direct AOI**. These impacts are expected to be **Continuous** but infrequent due to the low abundance of seabirds in the PDA throughout much of the year (highest bird abundance occurs during spring and fall migration) and the fact that only some of the exposed individuals would be affected by the attraction-related impacts described above. The potential for the impact will be present throughout the Project life cycle (at least 20 years), yielding a duration of **Long-term** for drilling, installation, and production operations phases, and at least **Medium-term** for the decommissioning stage. This yields a magnitude rating of **Small** for potential impacts on seabirds from attraction to Project features during the production operations phase, and **Negligible** during the drilling, installation, and decommissioning phases of the Project.

The drill ships, major installation vessels, and FPSO may be of benefit to some species that use the vessels for rest or shelter during long flights or adverse weather. Additionally, major vessels in the PDA could become an attractant for seabird prey (i.e., due to lighting) during the production operations stage. These are considered potential minor **Positive** impacts. These benefits will be most pronounced for the FPSO, as the FPSO will remain in the same location for the Project life cycle (at least 20 years). For this reason, seabirds are likely to become familiar with the location of this potential resting/prey location, and use may increase over time, as compared to mobile vessels operating in the area over a relatively short-time span during the drilling and installation stages. Decommissioning activities for the FPSO and related vessel traffic may impact seabirds in similar ways to that described for the installation and production operations stages but for a much shorter duration. The removal of the FPSO will eliminate the potential benefits from acting as a resting location or prey attractant but, as described above, the benefits are expected to be minor, and seabirds are expected to quickly adapt to this change. As such, the intensity, and therefore magnitude, of the impact of a loss of a resting play or prey attract as a result of removal of the FPSO during decommissioning on seabirds is rated as **Negligible**.

Disturbance Related to Project Activities and Features

Seabirds are not known to be particularly sensitive to human activity, so increased human activity in the PDA is expected to have little impact. As such and similar to that described for the attraction effects above, the intensity of this impact on seabirds is rated as **Low** for the production operations phase and **Negligible** for the drilling and decommissioning phases of the Project. Project activities that could result in disturbance or avoidance behavior by seabirds will decrease during the production operations stage, so potential disturbance of seabirds will decrease as well. There will be a small increase in human activity during decommissioning, but that increase will be of relatively short duration and will not rise to the same level of activity

associated with drilling and installation. Since any seabird occurring in the **Direct AOI** may experience disturbance from the presence of Project activities and features, disturbance-related impacts are considered to be **Continuous** and **Long-term** for drilling, installation, and production operations phases, and at least **Medium-term** for the decommissioning phase. This yields a magnitude rating of **Negligible** to **Small** for potential impacts on seabirds from disturbance from Project activities and features (Table 7.4-9).

Table 7.4-9: Magnitude of Impact—Seabirds

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Development Well Drilling Subsea, Umbilicals, Risers, and Flowlines / FPSO Installation	Seabirds—direct mortality or injury from attraction to offshore Project facilities	Direct AOI	Negligible	Continuous	Long-term	Negligible
	Seabirds—light and sound disturbance from Project activities	Direct AOI	Negligible	Continuous	Long-term	Negligible
Production Operations	Seabirds—direct mortality or injury from attraction to offshore Project facilities	Direct AOI	Low	Continuous	Long-term	Small
	Seabirds—light and sound disturbance from Project activities	Direct AOI	Low	Continuous	Long-term	Small
Decommissioning	Seabirds—direct mortality or injury from attraction to offshore Project facilities	Direct AOI	Negligible	Continuous	Medium-term	Negligible
	Seabirds—light and sound disturbance from decommissioning activities	Direct AOI	Negligible	Continuous	Medium-term	Negligible
	Removal of the FPSO as a resting place or attractant of prey	Direct AOI	Negligible	Continuous	Medium-term	Negligible

7.4.3.3. Sensitivity of Receptor—Seabirds

Seabirds are expected to occur in the PDA throughout the year, but at low densities and primarily as transients moving with prey resources. All but 2 of the 35 species of seabirds known to occur offshore Guyana and the Stabroek Block are listed on the IUCN Red List as Least Concern or Data Deficient. Since the majority of birds that occur in the Direct AOI do not have elevated conservation status, the determination of sensitivity of seabirds to potential impacts

was conducted based on life history and behavior and, hence, their susceptibility to impacts. As stated in Section 7.4.2.1, Background, seabirds in the PDA area are likely to be transients, moving opportunistically with prey or making seasonal dispersal movements or migrations. All survey data conducted to date through EEPGL-commissioned surveys and incidental observations indicate that birds do not congregate in the Stabroek Block, but rather pass through the area as lone individuals or occasionally in pairs. Table 7.4-10 provides definitions for the receptor sensitivity ratings for potential impacts on seabirds. These definitions apply for only those species rated as Least Concern, Data Deficient, or not assessed on the IUCN Red List. Species rated as Near Threatened or higher, specifically the two species of seabirds with elevated conservation status known to occur offshore Guyana—Leach's Storm-Petrel and the Black-capped Petrel—are addressed in Section 7.1, Protected Areas and Special Status Species. Based on the definitions shown in Table 7.4-10, non-special status seabirds are considered to have a **Low** sensitivity.

Table 7.4-10: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Seabirds

Criterion	Definition
Sensitivity	Low: No seabird species known or expected to occur in the PDA possess unique susceptibilities to Project-related impacts. Impacts, should they occur, would be to individual birds and not congregations of birds.
	Medium: One or a limited number of seabird species with elevated susceptibility to Project-related impacts due to prolonged or regular presence in the PDA, and/or one or a limited number of species that exhibit habitat preferences or behaviors that limit their ability to avoid Project-related impacts, but representing a small fraction of the regional or global populations of affected species.
	High: Several seabird species with elevated susceptibility to Project-related impacts due to prolonged or regular presence in the PDA, and/or several species that exhibit habitat preferences or behaviors that greatly limit their ability to avoid Project-related impacts, representing a substantial fraction of the regional or global populations of affected species.

7.4.3.4. Impact Significance—Seabirds

Based on the magnitude of impact of receptor sensitivity ratings described above, the pre-mitigation significance ratings for potential (adverse) impacts on seabirds range are rated as **Negligible** (see Table 7.4-12).

7.4.4. Management Measures—Seabirds

The embedded controls, such as use of directional lighting to the extent practicable, that are integrated into the Project design and operational procedures constitute the practicable measures that are available to reduce the significance of potential impacts on seabirds. Table 7.4-11 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 7.4-11: List of Embedded Controls and Monitoring Measures

Embedded Controls
When non-aqueous drilling fluid (NADF) is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.
For all vessel effluent discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage), comply with International Maritime Organization / International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 milligrams per liter (mg/L) on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored, and the discharge meets the noted specification.
Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3°C (5.4°F) at 100 meters (approximately 328 feet) from discharge point.
Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals.
Monitor residual chlorine concentration of sewage discharges form the FPSO monthly to stay below 0.5 mg/L in accordance with MARPOL 73/78 regulations.
Perform daily visual inspections on the FPSO of discharge points to verify that there are no floating solids or discoloration of the surrounding waters.
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.
Implement chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances and consider the Offshore Chemical Notification Scheme as a resource for chemical selection in Project production operations. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes: • Reviewing Safety Data Sheets; • Evaluating alternate chemicals; • Considering hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals – Considering minimum safety risk relative to flammability and volatility • Evaluating risk of residual chemical releases into the environment.
For effluent released from the onboard sewage treatment plant, comply with aquatic discharge standards in accordance with MARPOL 73/78 regulations.
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter particle size or less) prior to discharge.
Confirm there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge. Perform daily inspections to verify no visible sheen from discharge of cooling water.
Treat bilge water in accordance with MARPOL 73/78 to comply with an oil-in-water content of less than 15 parts per million (ppm), as applicable.
Where reasonably practicable, direct lighting on FPSO and major Project vessels to required operational areas rather than at the sea surface or skyward. Adhere to maritime safety regulations/standards for lighting on vessels.

Mitigation Measures
Following start-up of production operations, implement a program to characterize effluent water discharges from the FPSO and conduct an environmental risk assessment based on the characterization data. As appropriate based on the results of the environmental risk assessment, implement additional treatment options, if warranted and feasible.
Monitoring Measures
Prior to and post-drilling, a remotely operated vehicle will take pictures of the area immediately surrounding the well location to monitor for marine water quality impacts.
Monitor daily during drilling to confirm that end of well maximum weighted mass ratio averaged over all well sections drilled using non-aqueous base fluid shall not exceed 6.9 percent wet weight base fluid retained on cuttings.
Monitor daily produced water discharge volume.
Measure oil and grease content of produced water (grab sample once per day).
Perform daily inspections to verify no visible sheen from discharge of cooling water.
Monitor discharge temperature of cooling water and produced water to avoid increases in ambient water temperature of more than 3°C (5.4°F) at 100 meters (approximately 328 feet) from point of discharge.
Use load-monitoring system in the FPSO control room to support FPSO offloading.
Monitor pressure and temperature of subsea wells and manifolds by a control system on the FPSO to detect and prevent leaks.
Monitor chlorine concentration of treated sewage discharges.
Perform daily visual inspection of discharge points to verify absence of floating solids or discoloration of the surrounding waters.
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book.
Perform oil in water content (automatic) monitoring of bilge water to comply with 15 ppm MARPOL 73/78 limit and record in Oil Record Book.
Record estimated volume of ballast water discharged and location (per ballasting operation).

Table 7.4-12 summarizes the assessment of potential pre-mitigation and residual Project impacts on seabirds. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the seabird-specific methodology described in Sections 7.4.3.2, Magnitude of Impacts—Seabirds, and 7.4.3.3, Sensitivity of Receptor—Seabirds.

Table 7.4-12: Summary of Potential Pre-Mitigation and Residual Impacts—Seabirds

Stage	Receptor—Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Well Drilling Subsea, Umbilicals, Risers, and Flowlines / FPSO Installation	Seabirds—direct mortality or injury from attraction to offshore Project facilities	Negligible	Low	Negligible	None	Negligible
	Seabirds—light and sound disturbance from Project activities	Negligible	Low	Negligible	None	Negligible
Production Operations	Seabirds—direct mortality or injury from attraction to offshore Project facilities	Small	Low	Minor	None	Minor
	Seabirds—light and sound disturbance from Project activities	Small	Low	Minor	None	Minor
	Seabirds—benefit from use of major vessels as a resting place or attractant of prey	Not rated, (Positive)	Low	Positive	None	Positive
Decommissioning	Seabirds—direct mortality or injury from attraction to offshore Project facilities	Negligible	Low	Negligible	None	Negligible
	Seabirds—light and sound disturbance from Project activities	Negligible	Low	Negligible	None	Negligible
	Seabirds—removal of FPSO as a resting place or attractant of prey	Negligible	Low	Negligible	None	Negligible

7.5. MARINE MAMMALS

7.5.1. Administrative Framework—Marine Mammals

Table 7.5-1 summarizes the legislation, policies, treaty commitments, or that are specifically relevant to the assessment of potential impacts on marine mammals.

Table 7.5-1: Legislation, Policies, or Treaty Commitments—Marine Mammals

Title	Objective	Relevance to the Project
Legislation		
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013; the Wild Birds Protection Act, 1987; and the Species Protection Regulations, 1999)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a framework to address the national goals for wildlife protection, conservation, and management. The Act also provides recommendations on measures for the protection of threatened ecosystems and habitats, and advises on measures for conservation of biological diversity.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity (signed in 1992, ratified in 1994)	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Encourages Project design and execution so as to protect and conserve biological diversity.
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (Guyana acceded and ratified in 2010)	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection of the marine environment, especially from possible pollution.

7.5.2. Existing Conditions—Marine Mammals

A basic understanding of the existing species composition and distribution of the marine mammal community in the vicinity of the PDA and in the Stabroek Block is provided by various sources, including regional compilations (Ward et al. 2001; Ward and Moscrop 1999), Marine Mammal Observer (MMO) data collected during EEPGL's exploration activities from 2015 to 2021, published studies on cetaceans in offshore waters of neighboring countries (Suriname and Venezuela; de Boer 2015), and incidental commercial fishery interaction reports (Project GloBAL 2007).

Information from these reports and other studies provides the foundation for the existing conditions on cetaceans offshore Guyana. At one time, two pinniped groups (seals and sea lions) were documented in the region, but they are now considered extinct or extremely rare in

the region. Therefore, pinnipeds are not expected to be encountered in coastal waters adjacent to the PDA (Ward et al. 2001).

EEPGL's PSO data were collected by PSOs participating in various programs offshore Guyana during 2015 through 2021. Data were collected during five survey types—three-dimensional (3D)/four-dimensional (4D) surface seismic; field geotechnical; automated underwater vehicle (AUV); vertical seismic profile (VSP); and environmental baseline/metocean. The PSO data collection effort considered for the purpose of this assessment consisted of the following:

- 3D/4D surface seismic
  - Stabroek 3D: 12 July 2015 to 17 February 2016
  - Canje 3D: 18 March 2016 to 20 August 2016
  - Liza 3D/4D: 23 August 2017 to 19 November 2017
  - Northwest Stabroek and Southeast Stabroek *Ramform Tethys* and *Ramform Atlas*: 05 December 2018 to April 2019
- Field geotechnical survey
  - Canje: 28 July 2018 to 28 September 2018
  - Liza: 28 July 2018 to 28 September 2018
  - Payara Geotechnical, Geophysical/AUV and Environmental Baseline: 05 September 2018 to 27 December 2018
  - Hammerhead Geotechnical Survey: 06 March 2020 to 14 March 2020
  - Hammerhead Geotechnical Survey: 01 April 2020 to 07 April 2020
  - Nearshore Geotechnical and Geophysical Survey: 24 October 2020 to 29 October 2020
- AUV
  - Liza AUV: 17 December 2015 to 23 March 2016
  - Hammerhead AUV: 16 March 2019 to 17 April 2019
  - Stabroek Multi AUV Geophysical Survey: 14 December 2019 to 05 May 2020
- VSP
  - Liza-1 Stabroek Zero-Offset VSP: 09 May 2015 to 12 May 2015
  - Liza-1 Stabroek Walk Away VSP: 06 June 2015 to 08 June 2015
  - Liza-2 Stabroek Walk Above VSP: 28 March 2016 to 01 April 2016
  - Payara-1 Stabroek Zero-Offset VSP: 04 December 2016 to 05 December 2016
  - Stabroek VSP 1: 29 September 2017 to 02 October 2017
  - Stabroek VSP 2: 15 December 2017 to 17 December 2017
  - Stabroek VSP 3: 03 January 2018 to 08 January 2018
  - LongTail-1 *Stena Carron* Zero Offset VSP: 02 June 2018 to 06 June 2018
  - LongTail-1 *Bourbon Orca* Walk-Away VSP: 15 June 2018 to 20 June 2018
  - Hammerhead *C-Installer* Walk-Away VSP: 28 August 2018 to 30 August 2018
  - Pluma-1 *Noble Tom Madden* VSP: 12 November 2018 to 16 November 2018
  - Pluma-1 *PSV Eland* VSP: 28 November 2018 to 29 November 2018
  - Pluma-1 *PSV Eland* VSP: 11 December 2018 to 13 December 2018
  - Stabroek *Stena Carron* VSP: 23 January 2019 to 03 February 2019

- Stabroek *Noble Tom Madde*n VSP: 07 April 2019 to 08 April 2019
- Stabroek *Noble Tom Madden* VSP: 17 April 2019 to 19 April 2019
- Canje VSP 1: 16 January 2021 to 22 February 2021
- Stabroek *Noble Don Taylor* SC VSP: 17 May 2021 to 18 May 2021

- Environmental Baseline and Metocean Surveys
  - Liza Environmental Baseline Survey (EBS) 1: 27 September 2017 to 02 October 2017
  - Liza EBS 2: 18 October 2017 to 28 October 2017
  - Liza EBS 3: 28 October 2017 to 20 November 2017
  - Liza EBS 4: 19 March 2018 to 16 April 2018
  - *Sea Service* Metocean Retrieval Survey: 01 October 2018 to 06 October 2018
  - Canje Block EBS: 17 September 2018 to 24 September 2018
  - Southeast Stabroek / Kaieteur *Proteus* EBS: 08 April 2019 to 15 April 2019

7.5.2.1. Regional Setting

The equatorial waters of Guyana are located within sub-region VI of the Wider Caribbean Region. This sub-region includes the countries of Guyana, Suriname, and French Guiana (Ward and Moscrop 1999). Many cetacean species are known to occur either seasonally or year-round in the Caribbean region, but there are limited data describing the life history, behavior, and movement patterns of most marine mammals offshore Guyana. The cetacean community is also under-recorded in waters off of French Guiana (de Boer 2015; Mannocci et al. 2013). In contrast, more detailed records exist for Venezuela and the southern Caribbean region. It should be noted that the scarcity of cetacean records for sub-region VI can be attributed to a lack of survey effort rather than an absence of marine mammals (de Boer 2015).

7.5.2.2. Marine Mammal Data from the Project Development Area Vicinity

Historical Marine Mammal Data from the Guianas Region

The 2007 Global Bycatch Assessment of Long-lived Species Country Profile of Guyana (Project GloBAL 2007) provides a list of marine mammals whose distributions overlap with Guyana's Exclusive Economic Zone (EEZ). The cetacean species documented in this report are listed in Table 7.5-2 along with their IUCN Red List status (IUCN 2021).

Table 7.5-2: Marine Mammals with Ranges that include Waters Offshore Guyana

Common Name	Scientific Name	IUCN Status	Notes
Sei whale	*Balaenoptera borealis*	EN	The sei whale is a baleen whale that prefers temperate waters in the mid-latitude range of the Atlantic, Pacific, and Indian oceans. It is the third-largest whale after the blue whale and the fin whale.
Bryde's whale	*Balaenoptera edeni*	LC	Bryde's whales are moderately sized and closely resemble their relative, the sei whale.
Blue whale	*Balaenoptera musculus*	EN	Blue whales are the largest mammals on earth. Their diet consists almost entirely of krill. Blue whales were hunted nearly to extinction.

Common Name	Scientific Name	IUCN Status	Notes
Fin whale	*Balaenoptera physalus*	VU	Fin whales are the second largest mammal after blue whales. They are found worldwide and their food consists of small fish, squid, copepods, and krill.
Minke whale	*Balaenoptera acutorostrata*	LC	Minke whales are the second smallest baleen whale.
Common dolphin	*Delphinus delphis*	LC	Common dolphins occur throughout warm temperate and tropical oceans. Common dolphins can occur in aggregations of hundreds or even thousands of dolphins. They sometimes associate with other cetacean species, such as pilot whales.
Long-beaked common dolphin[17]	*Delphinus capensis*	DD	Long-beaked common dolphin is more geographically restricted (i.e., smaller in area) than that of the common dolphin. It has a varied diet. One of the main threats to this dolphin is fishery by-catch.
North Atlantic right whale	*Eubalaena glacialis*	CR	The North Atlantic right whale is a baleen whale that was once a preferred target for whalers. They feed mostly on copepods and krill.
Pygmy killer whale	*Feresa attenuata*	LC	The pygmy killer whale is a poorly known and rarely seen dolphin that avoids human contact. They are often caught in drift gill nets.
Short-finned pilot whale	*Globicephala macrorhynchus*	LC	Short-finned pilot whales are very sociable and are rarely seen alone. They are found in groups of 10 to 30, although some pods are as large as 50. The species primarily feeds on squid, but will also feed on certain species of fish and octopus. They feed nearly 300 meters (approximately 984 feet) deep or more, and spend great lengths of time at depth. A pod may spread out up to 800 meters (approximately 2,640 feet) to cover more area to find food.
Risso's dolphin	*Grampus griseus*	LC	Risso's dolphins are found worldwide in temperate and tropical waters, just off the continental shelf on steep banks. Risso's dolphins feed almost exclusively on neritic and oceanic squid, mostly nocturnally.
Pygmy sperm whale	*Kogia breviceps*	LC	The pygmy sperm whale is not much larger than many dolphins. Pygmy sperm whales are normally either solitary or found in pairs. They feed mainly on cephalopods.
Dwarf sperm whale	*Kogia simus*	LC	The dwarf sperm whale is the smallest species commonly known as a whale. Dwarf sperm whales feed mainly on squid and crab. Their preferred habitat appears to be just off the continental shelf.

[17] The taxonomic status of Long-beaked common dolphin is currently the subject of debate. The IUCN and the Society for Marine Mammalogy Committee on Taxonomy consider it a subspecies of *Delphinus delphis*, but acknowledge that it may eventually be listed as a separate species. It is listed separately here to maintain consistency with EEPGL's PSO reports and marine mammal database for Guyana waters.

Common Name	Scientific Name	IUCN Status	Notes
Fraser's dolphin	*Lagenodelphis hosei*	LC	Fraser's dolphin is normally sighted in deep tropical waters. Fraser's dolphins swim quickly in large, tightly packed groups of about 100 to 1,000 in number.
Humpback whale	*Megaptera novaeangliae*	LC	The humpback whale is found in oceans and seas around the world. Humpback whales typically migrate up to 25,000 kilometers (approximately 15,534 miles) each year. Humpbacks feed only in summer, in polar waters, and migrate to tropical or subtropical waters to breed and give birth in the winter. Once hunted to the brink of extinction, its population fell by an estimated 90% before a 1966 moratorium. Since this time, stocks have partially recovered.
Blainville's beaked whale	*Mesoplodon densirostris*	LC	Blainville's beaked whale is found in tropical and warm waters in all oceans, and has been known to range into very high latitudes. The whales are seen in groups of three to seven individuals. Dives have been measured as long as 22 minutes.
Gervais' beaked whale	*Mesoplodon europaeus*	LC	Gervais' beaked whale forms small groups. They most likely feed on squid. Although this species frequently strands, until 1998, no one had made a confirmed sighting of the species at sea.
True's beaked whale	*Mesoplodon mirus*	LC	True's beaked whales have been seen in small groups, and are believed to be squid eaters. Little else is known.
Melon-headed whale	*Peponocephala electra*	LC	Melon-headed whale is closely related to the pygmy killer whale and pilot whale, collectively this dolphin species is known by the common name blackfish. It is also related to the false killer whale. The melon-headed whale is widespread throughout the world's tropical waters, although not often seen by humans because it prefers deep water.
Sperm whale	*Physeter macrocephalus*	VU	The sperm whale is the largest of the toothed whales that can be found anywhere in the open ocean. Females and young males live together in groups while mature males live solitary lives outside of the mating season. Females give birth every 4 to 20 years and care for the calves for more than a decade. A mature sperm whale has few natural predators. They feed on squid and fish and usually dive between 300 to 800 meters (984 to 2,625 feet) to forage.
False killer whale	*Pseudorca crassidens*	NT	False killer whales live in temperate and tropical waters throughout the world. As its name implies, the false killer whale shares characteristics, such as appearance, with the more widely known killer whale. Like the killer whale, the false killer whale attacks and kills other cetaceans.
Pantropical spotted dolphin	*Stenella attenuata*	LC	Pantropical spotted dolphin is found in the world's temperate and tropical oceans. This species was threatened due to the killing of millions of individuals

Common Name	Scientific Name	IUCN Status	Notes
			in tuna purse seines until the rise of "dolphin-friendly" tuna capture methods in the 1980s benefited the species. It is now one of the most abundant dolphin species in the world.
Clymene dolphin	*Stenella clymene*	LC	Clymene dolphins spend most of their lives in waters more than 100 meters (330 feet) in depth, but occasionally move into shallower, coastal regions. They feed on squid and small schooling fish, hunting either at night, or in mesopelagic waters where there is only limited light.
Striped dolphin	*Stenella coeruleoalba*	LC	The striped dolphin inhabits temperate or tropical, offshore waters. It moves in large groups—usually up to thousands of individuals in number. The adult striped dolphin eats fish, squid, octopus, krill, and other crustaceans.
Spinner dolphin	*Stenella longirostris*	LC	The spinner dolphin is a small dolphin found in offshore tropical waters around the world. The species primarily inhabits coastal waters, islands, or banks.
Rough-toothed dolphin	*Steno bredanensis*	LC	Rough-toothed dolphins can be found in deep warm and tropical waters around the world and are typically social animals. An average group has between 10 and 20 members. They have also been reported to school together with other species of dolphin, and with pilot whales, false killer whales, and humpback whales.

Sources: Project GloBAL 2007; de Boer 2015; IUCN 2021; Minasian et al. 1984

CR = Critically Endangered; EN = Endangered; LC = Least Concern; NT = Near Threatened; VU = Vulnerable; DD (Data Deficient) = Inadequate information to make a direct, or indirect, assessment of a species' risk of extinction based on its distribution and/or population status.

In 2015, the Dutch Institute for Marine Resources and Ecosystem Studies published a peer-reviewed article summarizing marine mammal data collected off Suriname (de Boer 2015). The data were collected at depths and distances offshore similar to the PDA, and included observations in 2012 from an offshore survey area, and incidental observations off Suriname and adjacent waters from 2008 to 2012 (de Boer 2015). The study documented ten identifiable species. The article also documented incidental sightings of various marine mammals, including common bottlenose dolphins (*Tursiops truncatus*) off Trinidad, dolphins (*Stenella* sp.) off Guyana, and Guiana dolphin (*Sotalia guianensis*) at the entrance of the Suriname River during transit to the survey area (from Trinidad to Suriname). Thus, it is possible these species may be encountered closer to shore where Project-related marine support vessels are expected to transit.

De Boer (2015) reported the cetacean community in the Suriname area as primarily composed of odontocetes (toothed whales, sperm whales, beaked whales, killer whales, and dolphins). In general, these animals are more common offshore of Suriname than the baleen whales. De Boer (2015) noted that the most abundant species documented offshore Suriname were sperm whale (*Physeter macrocephalus*) and melon-headed whale (*Peponocephala electra*).

Spinner dolphin (*Stenella longirostris*) and pantropical spotted dolphin (*Stenella attenuata*) were also frequently encountered in large groups.

Other older reports provide additional information for context. For example, the International Whaling Commission Scientific Committee has published data from Venezuela (Bolaños-Jiménez et al. 2006) and French Guiana (Ridoux et al. 2010). These reports indicate bottlenose dolphins are incidentally captured in gillnet and trawl fisheries in these countries. Gray river dolphin (*Sotalia fluviatilis*; locally referred to as tucuxi), despite being a primarily freshwater species, is also reported to be incidentally captured in gillnets and seines throughout its range, which includes the Guianas (French Guiana, Suriname, and Guyana). The American manatee (*Trichechus manatus*) is sparsely distributed in coastal and riverine waters of the region, including the Demerara River. This species is discussed in more detail in Section 7.6, Riverine Mammals.

EEPGL-Commissioned Marine Mammal Data

As summarized above, EEPGL has commissioned the collection of marine mammal data offshore Guyana since 2015, during various survey activities related to oil and gas activities. Data on marine mammals have been collected using visual and auditory detection methods. Together, these survey efforts represent more than 19,000 hours of survey time and have generated the most comprehensive dataset available on marine mammal activity off the coast of Guyana (RPS 2018; RPS 2019).

A comprehensive summary of PSO data from 2015 through April 2018 was provided as part of the Liza Phase 2 Development Project EIA (RPS 2018). A subsequent summary of PSO observations from May 2018 through April 2019 was provided as part of the Payara Development Project EIA (RPS 2019). Six additional PSO surveys have been conducted since the second summary report was published, only one of which detected marine mammals. This survey occurred between 14 December 2019 and 21 May 2020, and the report from this survey is included as Appendix N, ExxonMobil Multi AUV Geophysical Survey Protected Species Observer Summary Report.

Overview of December 2019 through May 2021 Marine Mammal Survey Data

Between December 2019 and May 2021, PSOs conducted 1,818 hours and 57 minutes of visual observations. No acoustic monitoring was conducted during this time. In total, 136 individual animals were detected in 23 detection events (Figure 7.5-1). Dolphins (n = 129 detections or 95 percent of detections, including 31 unidentified dolphins) were the taxonomic group most frequently detected by observers, followed by whales (n = 5 detections or 4 percent) and marine turtles (n = 2 detections or 1 percent). The most frequently identified dolphin species was common bottlenose dolphin (n = 83 or 61 percent of total observations), though 12 pantropical spotted dolphins (9 percent of total observations) and three Atlantic spotted dolphin (*Stenella frontalis*) were also observed (2 percent of total observations). Overall, the estimated visual detection rate based on 1,818.95 hours and 136 detection events was 0.0748 detection per hour of monitoring effort.

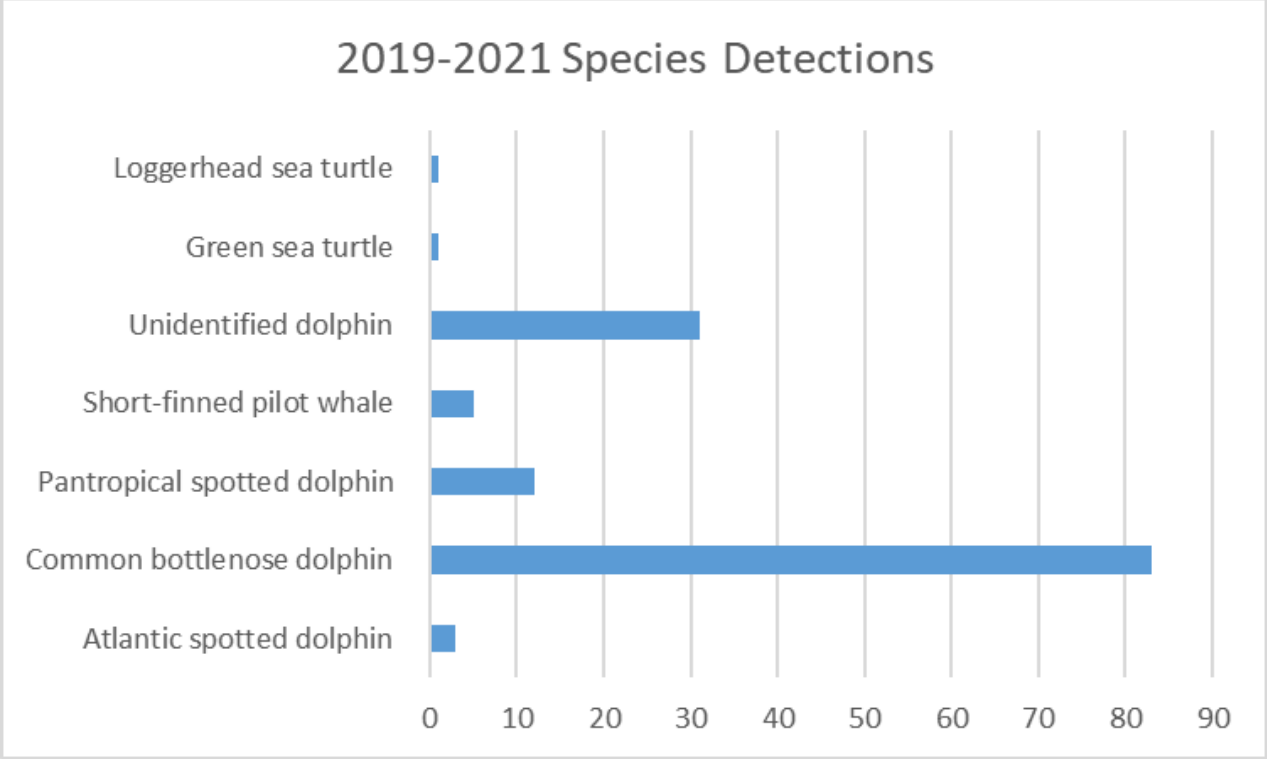


Figure 7.5-1: Number of Protected Species Visually Documented 2019–2021

Overview of Marine Mammal Survey Data from EEPGL-commissioned Surveys Since 2015

Over the approximately 6-year study period since EEPGL initiated marine mammal surveys offshore Guyana (2015–2021), there have been 1,345 marine mammal detections (including unidentified dolphins and whales). Of these detections, 693 were identifiable to species (Figure 7.5-2). To date, 15 cetacean species have been confirmed as observed in the Stabroek Block. Figure 7.5-3 summarizes the locations of marine mammal sighting across the various surveys.

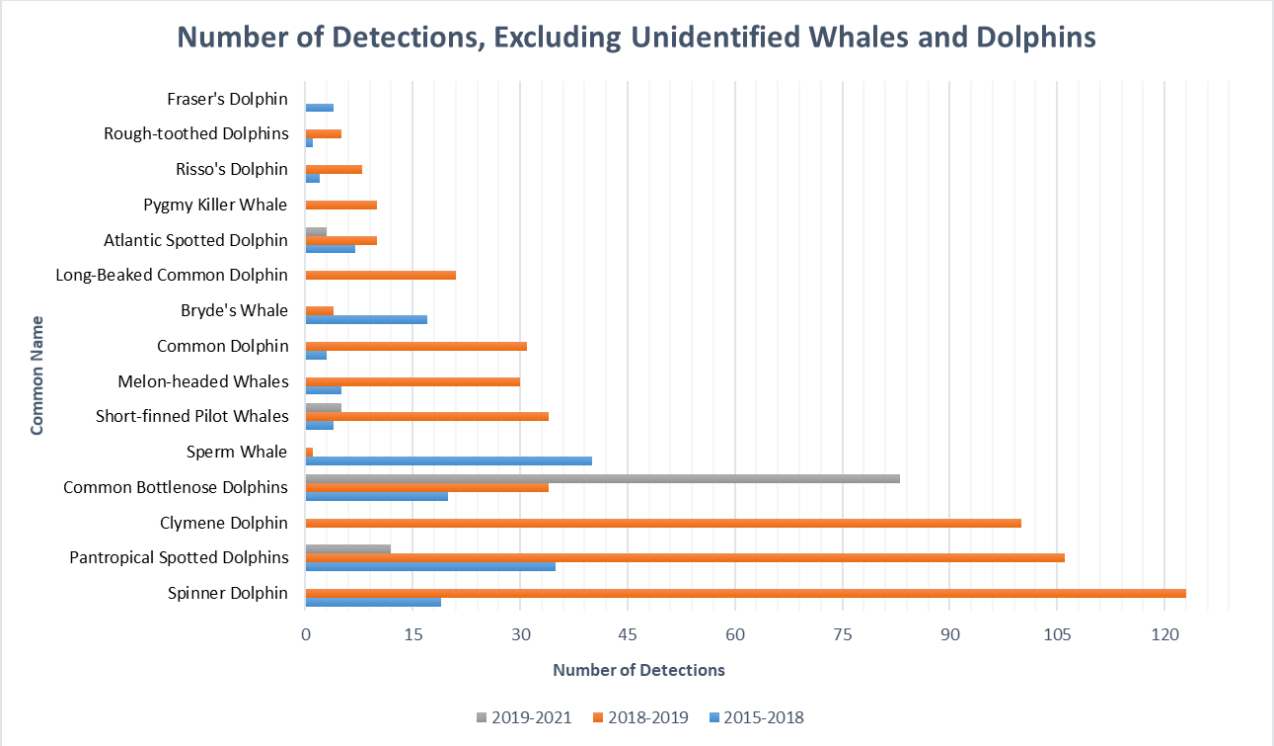


Figure 7.5-2: Confirmed Marine Mammal Sightings in the Stabroek Block, by Species for the 2015–2018, 2018–2019, and 2019–2021 Survey Periods

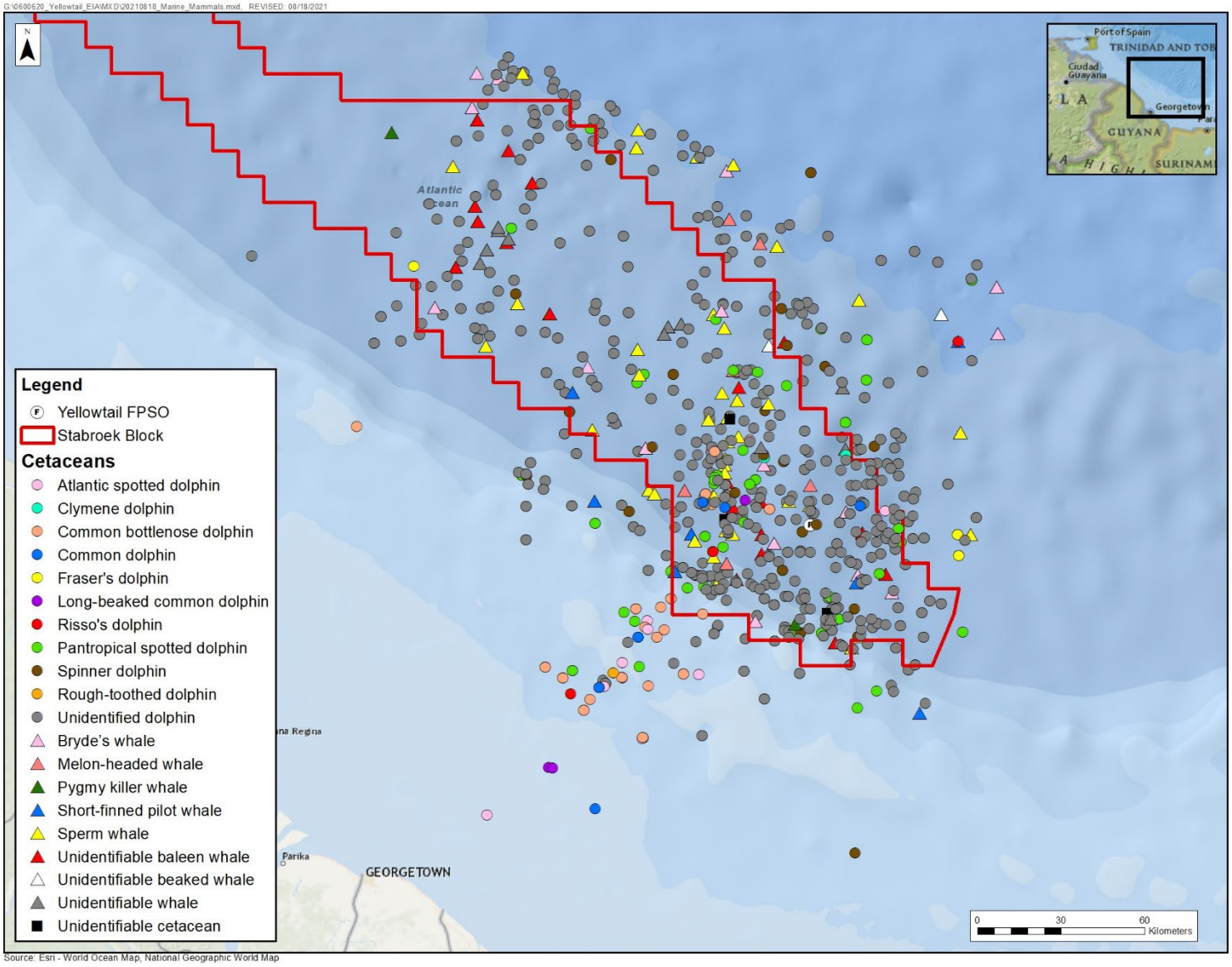


Figure 7.5-3: Locations of Marine Mammal Sightings Relative to the PDA (2015–2021)

Table 7.5-3 summarizes the species visually documented during the EEPGL-commissioned surveys. Most of the species identified are relatively common according to the IUCN (Least Concern status); it is noted, however, that several of the whales listed in Table 7.5-2 are globally rare (e.g., blue whale [*Balaenoptera musculus*], sei whale, North Atlantic right whale [*Eubalaena glacialis*]) and would not necessarily be expected to be detected, even though their historically documented range includes the survey area. It should also be noted this does not necessarily mean that rare or uncommon species listed in Table 7.5-2 do not occur in the Guyana EEZ; rather it means they are less likely to be detected if they occur in the area.

Table 7.5-3: Marine Mammal Species Visually Observed during EEPGL Activities (2015–2021)

Common Name	Scientific Name
Bryde's whale	*Balaenoptera brydei*
Sperm whale	*Physeter macrocephalus*
Melon-headed whale	*Peponocephala electra*
Short-finned pilot whale	*Globicephala macrorhynchus*
Pygmy killer whale	*Feresa attenuata*
Atlantic spotted dolphin	*Stenella frontalis*
Common bottlenose dolphin	*Tursiops truncatus*
Common dolphin	*Delphinus delphis*
Long-beaked common dolphin	*Delphinus capensis*
Fraser's dolphin	*Lagenodelphis hosei*
Pantropical spotted dolphin	*Stenella attenuate*
Risso's dolphin	*Grampus griseus*
Rough-toothed dolphin	*Steno bredanensis*
Spinner dolphin	*Stenella longirostris*
Clymene dolphin	*Stenella clymene*

Source: RPS 2019

Over the complete monitoring period (2015–2021), dolphins have accounted for over 80 percent of all detections. Unidentified dolphins were the most frequently detected group of marine mammals, accounting for 44 percent of all detections. After unidentified dolphin sightings, the most frequently detected marine mammal species were pantropical spotted dolphin, spinner dolphin, common bottlenose dolphin, and clymene dolphin, which together comprised 36.6 percent of all the detections over the monitoring period between. Short-finned pilot whales (*Globicephala macrorhynchus*), followed by sperm whales, were the most frequently detected species of whale (Figure 7.5-4). Marine mammal overall detection rates were similar across all surveys (0.0370, 0.0413, and 0.0748, detection per hour of monitoring effort for the periods 2015-2018, 2018-2019, and 2019-2021, respectively).

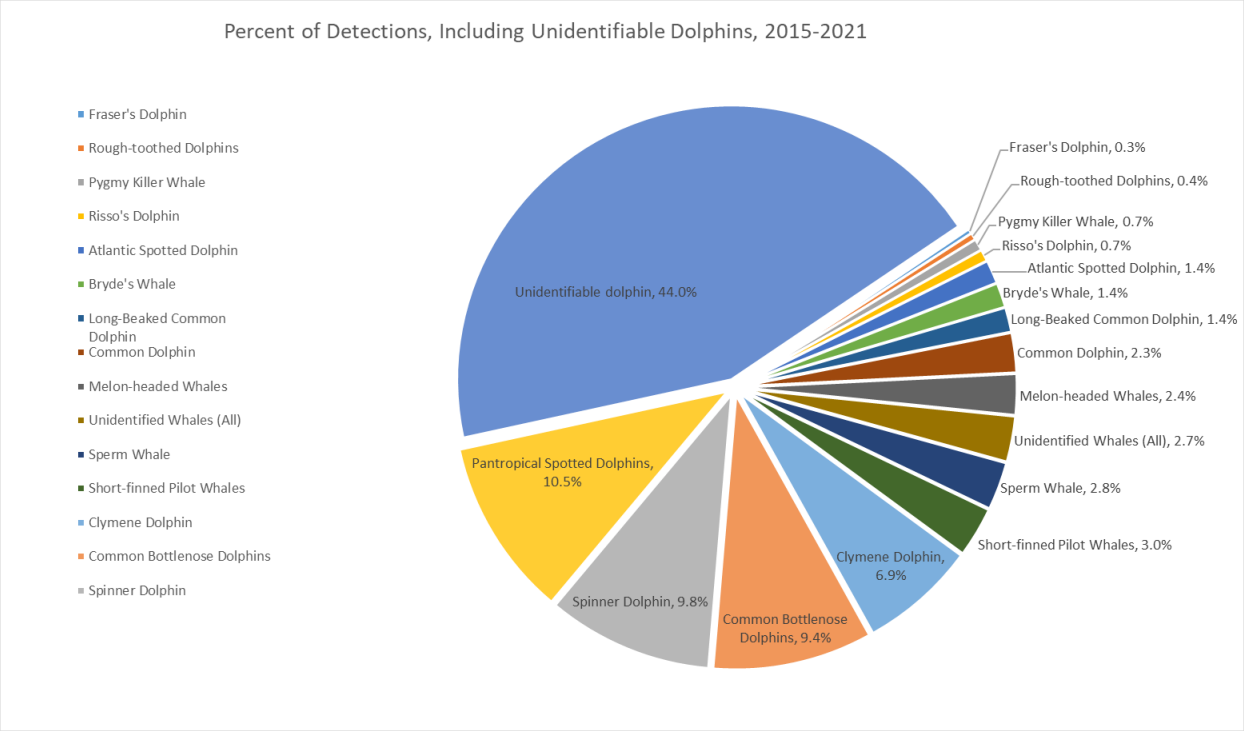


Figure 7.5-4: Distribution Sightings in the Stabroek Block by Species (2015–2021)

Detection rates by month for the survey period from 2015 through 2018 indicate toothed whale detections showed seasonal variability, with an increase in autumn and winter and a decrease in spring and summer (Figure 7.5-5). Accounting for the amount of survey effort, the seasonal pattern in detections (normalized per hour of observation) was consistent among years. Based on these detections, toothed whale abundance offshore Guyana likely varies with season. Some seasonal variability was observed in baleen whales, but the relatively small number of baleen whale detections compared to toothed whale detections makes comparisons between the two groups difficult.

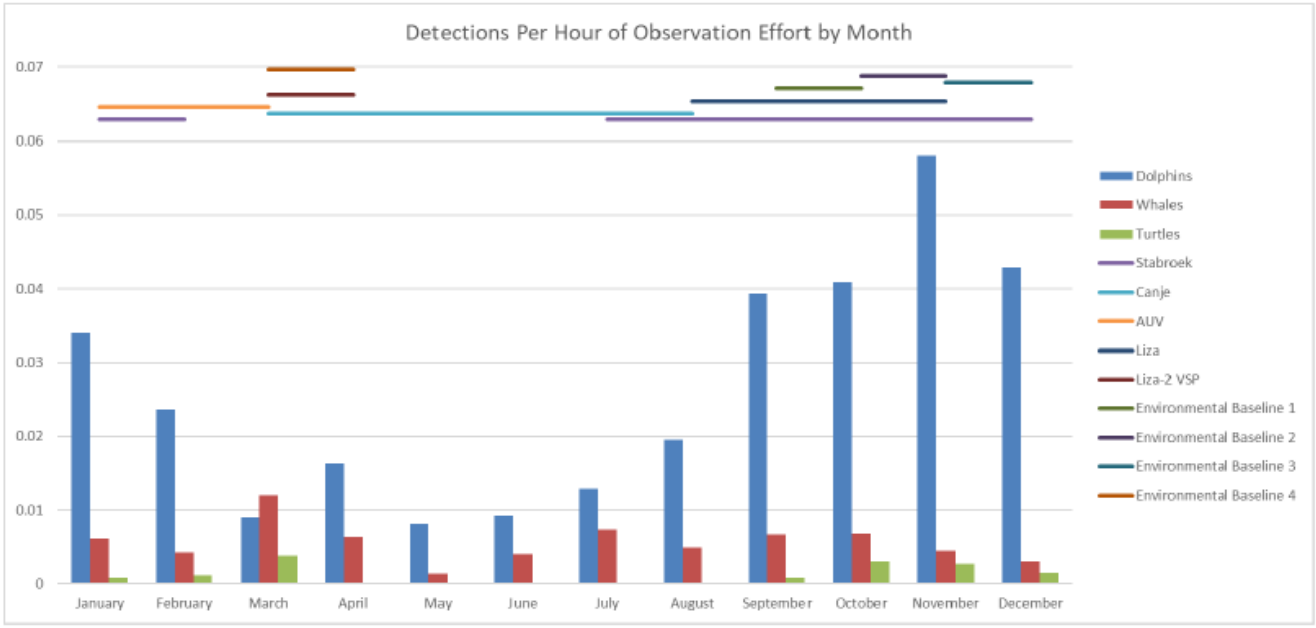


Figure 7.5-5: Seasonal Variations in Marine Mammal and Turtle Sightings in the Stabroek Block (2015–2018)

A survey of 125 nearshore Guyanese fisherfolk indicated they encounter various marine mammals, such as Amazon River dolphin (*Inia geoffrensis*; locally referred to as boto), tucuxi, spotted dolphin, common dolphin, spinner dolphin, and bottlenose dolphin (Charles et al. 2004). Although two of the six species mentioned in the captains' survey (botos and tucuxis) were not recorded in the EEPGL-commissioned surveys, the findings were generally consistent with the results from the EEPGL-commissioned surveys as follows:

- Botos and tucuxis are primarily associated with freshwater and—less frequently—estuarine environments, so these species are not expected to occur offshore where EEPGL-commissioned surveys took place.
- The fishing boat captains did not mention frequent encounters with any whale species.
- The Guyana fishing fleet has historically concentrated its efforts in comparatively shallow continental shelf waters, south of the EEPGL-commissioned survey areas.
- With the exception of two sightings of short-finned pilot whales a short distance south of the Stabroek Block in waters over the continental slope, the EEPGL-commissioned surveys did not document any whales farther south (i.e., shallower) than the Stabroek Block.

The combined findings of the EEPGL-commissioned surveys and the Charles et al. (2004) survey, suggest that the Project is likely near or southward of the southern boundary of the primary habitat for whales offshore Guyana; the Project is located in water depths of approximately 1,887 meters (approximately 6,190 feet). These findings also suggest that dolphins may be present throughout the Project AOI and at all times of the year; however, they are likely to be more abundant in the Project AOI in the autumn and winter months.

Figures 7.5-6 and 7.5-7 are photographs of marine mammals observed in the Stabroek Block during EEPGL-commissioned surveys in 2018 and 2019.

Photo credit: Meshach Pierre

Note: observed in the Stabroek Block during marine bird surveys conducted aboard the *Captain Grady*, April 2019

Figure 7.5-6: Common Bottlenose Dolphin (*Tursiops truncates*)

Photo credit: RPS 2019

Note: observed in the Stabroek Block from the *Sea Service*, October 2018

Figure 7.5-7: Rough-toothed Dolphin (*Steno bredanensis*)

7.5.3. Impact Assessment—Marine Mammals

As described above, toothed whales (short-finned, sperm, melon-headed whales) and dolphins (pantropical spotted, spinner, bottlenose, and clymene) are the marine mammal species most likely to be encountered in the PDA. Several other whale and dolphin species have also been observed in offshore waters in the PDA.

7.5.3.1. Relevant Project Activities and Potential Impacts

As shown in Table 7.5-4, the impact assessment considers the potential for planned Project activities to impact marine mammals either through injury (e.g., as a result of exposure to sound from Project activities), toxicological effects (e.g., as a result of exposure to Project vessel discharges), or disturbance leading to changes in behavior and reduced vigor (e.g., as a result of light, sound, and/or actions from Project activities). Potential impacts on marine mammals from unplanned events are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

Table 7.5-4: Summary of Relevant Project Activities and Key Potential Impacts—Marine Mammals

Stage	Activity	Key Potential Impact
Development Well Drilling Subsea, Umbilicals, Risers, and Flowlines / FPSO Installation, Commissioning, and Start-up	Vessel operations	Sound disturbance leading to deviation from area
	Power generation	Sound exposure leading to permanent threshold shift injury Sound disturbance leading to deviation from area
	VSP	
	Remotely operated vehicle operations	
	Lighting on drill ship and installation vessels	Offshore lighting is not considered to have a negative impact on marine mammals; it is considered to be an attractant for fish, and therefore a secondary attractant for some marine mammals.
	Permitted drill cuttings and fluids discharge	Exposures to permitted discharges, potentially leading to toxicological impacts
	Permitted effluent discharge	
Production Operations	Well stream production, processing, and storage operations	Sound disturbance leading to deviation from area
	Power generation	
	Permitted cooling and produced water discharge	Exposures to permitted discharges, potentially leading to toxicological impacts
	Permitted other liquid waste discharge	
	Lighting on FPSO	Offshore lighting is not considered to have a negative impact on marine mammals; it is considered to be an attractant for fish, and therefore a secondary attractant for some marine mammals.

Stage	Activity	Key Potential Impact
	Operation of tankers, tugs, and supply and support vessels	Sound disturbance leading to deviation from area
Decommissioning	Vessel operations	Exposures to permitted discharges, potentially leading to toxicological impacts. Sound disturbance leading to deviation from area

7.5.3.2. Magnitude and Sensitivity Definitions for Potential Impacts on Marine Mammals

Following the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude ratings of potential impacts on marine mammals are determined based on geographic extent, frequency, duration, and intensity.

The intensity of potential impacts on marine mammals from underwater sound is defined according to the definitions provided in Table 7.5-5.

Table 7.5-5: Definitions for Intensity Ratings for Potential Impacts on Marine Mammals

Criterion	Definition
Intensity	Negligible: No discernible change in marine mammal behavior or mortality.
	Low: Limited increases in injury or disturbance to marine mammals are perceptible, causing slight changes in the behavior of marine mammals.
	Medium: Increases in injury or disturbance to marine mammals are evident and may lead to irregular impacts on life functions (e.g., feeding, breeding, migration route changes) or, in very rare instances, mortality.
	High: Increases in injury or disturbance to marine mammals are sufficient to cause mortality or conditions of chronic behavioral changes impacting life functions.

As discussed in Section 7.1.3, Impact Assessment—Protected Areas and Special Status Species, because one of the marine mammals observed in the PDA (i.e., sperm whale) is listed as Vulnerable by IUCN, the marine mammals impact assessment was conducted based on the conservative assumption that this species would be the receptor for potential impacts. Accordingly, the receptor sensitivity ratings for special status species were used, as defined in Table 7.5-6. Based on the definitions defined below, the representative species assumed to be the receptor for potential impacts is considered to have a **Medium** sensitivity.

Table 7.5-6: Definitions for Receptor Sensitivity for Potential Impacts on Marine Mammals (Adopted from Potential Impacts on Special Status Species)

Criterion	Definition
Sensitivity	Negligible: Species with no scientifically recognized (e.g., IUCN Red List or regional equivalent) elevated conservation status or other specific value or importance attached to them.
	Low: Species and sub-species of Least Concern on the IUCN Red List (or not meeting criteria for medium or high value), or without specific anatomical, behavioral, or ecological susceptibilities to potential Project-related impacts.
	Medium: Species listed as Vulnerable or Near Threatened on the IUCN Red List; species protected under national legislation; nationally restricted range species;

Criterion	Definition
	nationally important numbers of migratory or congregatory species; species not meeting criteria for high value; and species vital to the survival of a medium value species.
	High: Species on IUCN Red List as Critically Endangered or Endangered; species having a globally restricted range (i.e., endemic species to a site, or found globally at fewer than 10 sites, fauna having a distribution range less than 50,000 square kilometers [19,305 square miles]), internationally important numbers of migratory or congregatory species, key evolutionary species, and species vital to the survival of high value species.

7.5.3.3. Characterization of Impacts—Injury or Disturbance from Underwater Sound

The main sources of underwater sound associated with development well drilling activities are from the VSP[18] activities (generating impulsive sound) and marine vessels (generating non-impulsive sound). The primary sources of sound from FPSO and Subsea, Umbilicals, Risers, and Flowlines (SURF) installation activities, production operations, and decommissioning activities are from marine vessels (generating non-impulsive sound).

Underwater sound can potentially cause a variety of impacts on marine mammals, such as behavioral changes in life functions (e.g., feeding, breeding, migration route deviations) or direct physical impacts affecting auditory systems.

Marine Mammal Auditory Functions

The potential for anthropogenic sound to impact marine animals depends on how well the animals can detect the sound and react. Sounds are less likely to be disruptive if they are at frequencies that animals cannot detect. However, when the sound pressure is high enough, it can cause physical injury through non-auditory mechanisms (i.e., barotrauma). For sound levels below such extremes, frequency weighting may be applied to scale the importance of sound components at particular frequencies in a manner reflective of an animal's sensitivity to those frequencies.

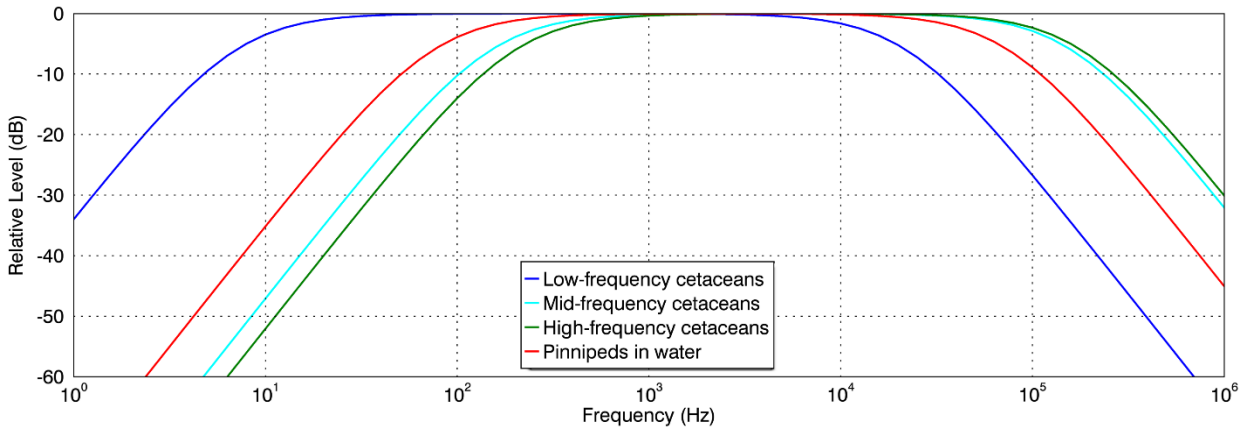
Auditory weighting functions for marine mammals, called M-weighting functions, were initially proposed by Southall et al. (2007) and then later modified by the U.S. National Oceanic and Atmospheric Administration (NOAA 2013) and Finneran (2015). For this assessment, values are presented using Southall et al. (2007) M-weighting functions and the weighting functions suggested by Finneran (2015).

[18] The VSP has a small source that produces seismic impulses over a period of time (for the purposes of this assessment, it was assumed that the source will produce 20 to 40 seismic pulses, less than 1 second in length, over a 6- to 12-hour period). The wavefield generated by this source is recorded by instruments in the borehole.

Southall et al. (2007) proposed M-weighting functions for five functional hearing groups of marine mammals:

- Low-frequency cetaceans (LFCs)—mysticetes (baleen whales);
- Mid-frequency cetaceans (MFCs)—some odontocetes (toothed whales);
- High-frequency cetaceans—odontocetes specialized for using high-frequencies;
- Pinnipeds in water[19]—seals, sea lions, and walruses (not addressed here); and
- Pinnipeds in air (not addressed here).

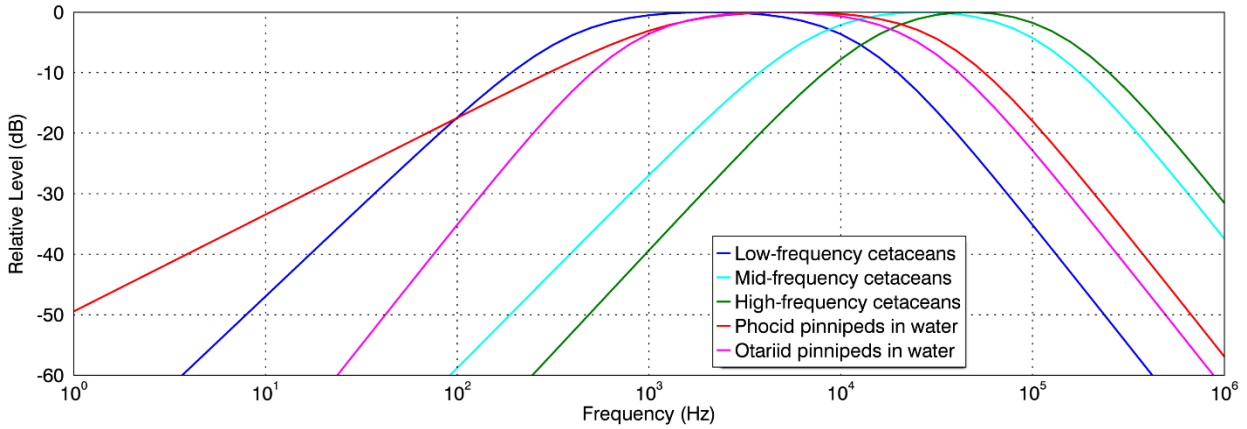
NOAA (2013) suggested further modifications to the LFC function, including two variations (for phocid and otariid pinnipeds) to the Southall et al. (2007) M-weighting function for pinnipeds in water. A U.S. Navy Technical Report (Finneran 2015) recommended new auditory weighting functions that consider the overall shape of the auditory weighting functions to be more like human A-weighting functions, which follow the sensitivity of the human ear at low sound levels. Although the inclusion of some species changed (e.g., the addition of hourglass [*Lagenorhynchus cruciger*] and Peale's [*Lagenorhynchus australis*] dolphins to the high-frequency functional hearing group), the five recommended functional hearing groups remain as presented in NOAA 2013. More information on the marine mammal auditory weighting functions described above, including the analytical formulation of these metrics, is provided in Appendix H, Underwater Sound Modeling Report.[20] The auditory weighting functions recommended by Southall et al. (2007) and Finneran (2015) are shown on Figure 7.5-8 and 7.5-9, respectively.



Source: JASCO 2016
Hz = hertz; dB = decibel

Figure 7.5-8: Auditory Weighting Functions for Marine Mammal Hearing Groups as Recommended by Southall el al. (2007)

[19] Pinnipeds were included in Southall et al. 2007, but are not relevant to this analysis of auditory impacts because pinnipeds are either likely extinct or extirpated offshore Guyana.
[20] The results of the 2016 study provided in Appendix H, Underwater Sound Modeling Report, (originally prepared for the Liza Phase 1 Project) have been determined to be appropriate for use in the underwater sound impact assessment for the Yellowtail Project (see discussion below).



Source: JASCO 2016
Hz = hertz; dB = decibel

Figure 7.5-9: Auditory Weighting Functions for Marine Mammal Hearing Groups as Recommended by Finneran (2015)

LFCs (including baleen whales) and MFCs (including dolphins and toothed whales) have been observed within or near the PDA, so this section only focuses on these marine mammal hearing groups.

Suction piles will be used to install the FPSO mooring spread and SURF foundations. A suction pile (or suction caisson) can be conceptually described as an upturned bucket that is embedded in the marine sediment by pushing or creating a negative pressure inside the caisson skirt. The technique requires underwater suction pumps to create a negative pressure between the bucket and the seafloor. Suction piling is regarded as a low-noise alternative to percussive piling techniques in the marine industry. Acoustic effects of suction piling operations have been experimentally determined to be undetectable within a few hundred meters of the source (Koschinski and Lüdemann 2020), and are used as primary noise reduction measures in jurisdictions with restrictive marine noise standards (Verfuss et al. 2019). Suction piles have been identified as a "preferred" alternative by the U.S. Bureau of Ocean Energy Management from an environmental perspective due to their smaller acoustic impacts compared to impact-based options (Fugro 2017). Prior modeling conducted for the Liza Phase I Development Project demonstrated that due to the water depths in Stabroek Block, the potential for acoustic injury from impact pile driving was minor. The Yellowtail Development Project will be located in deeper water than the Liza Phase 1 Development Project and will use suction piles, a low-noise alternative, instead of impact pile driving. Based on these factors, acoustic impacts from suction piling were not modeled for this EIA.

The acoustic modeling performed by JASCO for the Liza Phase 1 Development Project for impulsive and non-impulsive sound sources was leveraged for this EIA. JASCO conducted underwater sound modeling for the Liza Phase 1 Development Project EIA (JASCO 2016). For

the purpose of this EIA, JASCO compared the design, location, and layout of the Liza Phase 1 Project and the Yellowtail Project and made the following determination:

> "Therefore, based on the bathymetric relationship between the Liza Phase 1 and Yellowtail sound source locations, the homogeneous environmental properties over a large area that encompasses both the Liza and Yellowtail projects development areas, and the similarity in noise-producing activities for the two projects, we estimate that model results for the Yellowtail scenarios would present little changes in the distances to marine mammal injury thresholds provided for Liza Phase 1. Due to the deeper waters at Yellowtail, the distances are likely to be shorter than at Liza Phase 1." Appendix H, Underwater Sound Modeling Report)

Based on JASCO's determination (i.e., the results of the modeling analysis completed for the Liza Phase 1 Development Project were applicable to the impact assessment for the Yellowtail Project [and possibly conservative because the Yellowtail Project is in deeper water than the Liza Phase 1 Project and so even fewer marine mammals could be exposed to Project-related sound at levels of concern]), the maximum sound pressure level to which mammals could be exposed during the Yellowtail Development Project would not exceed 220 dB re 1 µPa² for impulsive sound and 180 dB re 1 µPa² for non-impulsive sound. The description of the modeling evaluation below (conservatively) references JASCO's original analysis for the Liza Phase 1 Development Project (JASCO 2016).

Impulsive sources (VSP) are typically brief and intermittent, with a rapid rise time and decay. In contrast, non-impulsive sources (marine vessels' main propulsion systems and internal machinery [e.g., generators, cranes]) can be brief or prolonged, and continuous or intermittent. However, one major difference is that non-impulsive sources do not have the high peak pressure and rapid rise time characterizing impulsive sounds.

Three complementary acoustic models (AASM[21], MONM[22], and FWRAM[23]) were used to predict underwater acoustic fields for the Project's potential sound sources. Based on available information, the model results were used to estimate the distances to marine mammal injury (permanent threshold shift [PTS][24]) thresholds. Source levels for the VSP were predicted using JASCO's AASM.

The VSP source considered was a six-element source array with a total volume of 1,200 cubic inches. The AASM produces a set of "notional" signatures for each array element based on the following:

- Source array layout;
- Volume, tow depth, and firing pressure of each element in the source array; and
- Interactions between different elements in the array.

[21] Airgun Array Source Model
[22] Marine Operations Noise Model
[23] Full Waveform Range-dependent Acoustic Model
[24] PTS is a sound-induced impact that results in a decrease in hearing sensitivity that is not expected to improve over time (OSHA 2013).

For the modeling, source-level spectra from measurements of surrogate vessels, including FPSOs, drill ships, pipelaying vessels, tugs, and support vessels, were adjusted to the specifications of the proposed Project vessels. Surrogate vessels were then chosen based on the similarity to the vessel specifications and types of operation for the Project.

Underwater sound propagation (i.e., transmission loss) was modeled with JASCO's MONM and FWRAM. The 3D acoustic fields were computed by modeling transmission loss within multiple 2D vertical planes extending from the source. The underwater sound fields were modeled for water column sound speed profiles during April, which has the historically lowest surface temperatures (colder water causes upward sound refraction and causes sound to travel further). Predicted sound fields were assessed across three dimensions, and the perceived sound level reported at each point in the horizontal plane was the maximum predicted sound level over all modeled depths for that point on the horizontal plane.

Based on these reported sound levels in the horizontal plane, two distance parameters were reported for each threshold:

- R_{max}, the maximum horizontal distance from the source where the predicted sound level reaches a threshold; and
- $R_{95\%}$, the maximum horizontal distance from the source where the predicted sound level reaches the threshold after the 5 percent of the predicted threshold-exceeding area farthest from the source is excluded. Regardless of the geometric shape of the "maximum-over-depth" footprint, $R_{95\%}$ is the predicted range encompassing at least 95 percent of the area (in the horizontal plane) that will be exposed to sound at or above the threshold.

To evaluate various operations, four scenarios were considered in this analysis:

6. The operation of an FPSO vessel;
7. The installation of the FPSO vessel, which includes mooring the FPSO and using several installation and service vessels;
8. Installation of a drill center, which includes the operation of a drill ship and a pipelaying vessel for the installation of SURF at a drill center; and
9. The completion of a VSP operation.

The sound footprint for each scenario was modeled to estimate the above-referenced distance parameters assuming thresholds are equal to the injury criteria prescribed by Southall et al. (2007) and Finneran (2015). The sound footprints were calculated as frequency-weighted (M-weighted) sound exposure levels (SELs) assuming 24 hours of operation. The sound footprints account for source-specific sound emission characteristics and site-specific environmental parameters.

Additional information on the underwater sound modeling methodology, including a detailed description of all model input parameters and approximate locations of modeled sources for all scenarios is provided in Appendix H, Underwater Sound Modeling Report.

Underwater Sound Criteria

Potential auditory impacts of planned Project activities on marine mammals were evaluated using Southall et al. (2007) and Finneran (2015) acoustic threshold levels for onset of PTS in LFCs and MFCs (Table 7.5-7).

Table 7.5-7: Acoustic Threshold Levels for Onset of PTS in Low-Frequency Cetaceans and Mid-Frequency Cetaceans

Marine Mammal Hearing Group	Estimated Auditory Bandwidth	PTS Onset Acoustic Thresholds (Injury Criteria)			
		Impulsive		Non-impulsive	
		Peak Sound Pressure Level (unweighted) (dB peak)	SEL (M-weighted) (SEL_{24h}; dB re 1 $\mu Pa^2.s$)	Peak Sound Pressure Level (unweighted) (dB peak)	SEL (M-weighted) (SEL_{24h}; dB re 1 $\mu Pa^2.s$)
Southall et al. 2007					
LFCs (baleen whales)	7 Hz to 22 kHz	230	198	230	215
MFCs (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz	230	198	230	215
Finneran 2015					
LFCs (baleen whales)	7 Hz to 25 kHz	230	192	Not available	207
MFCs (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz	230	187	Not available	199

µPa = microPascal; dB = decibel; Hz = hertz; kHz = kilohertz; m = meter; s = second; SEL_{24h} = 24-hour sound exposure level

Modeling Results

Tables 7.5-8 to 7.5-11 present the above-referenced distance parameters describing modeled horizontal distances to the point that Project-associated sound would attenuate to below PTS onset acoustic thresholds for LFCs and MFCs, according to Southall et al. (2007) and Finneran (2015) criteria, for the four above-referenced scenarios, respectively. Decommissioning activities were not subjected to underwater sound modeling, as activities during the decommissioning stage will be similar to those of SURF installation activities in terms of types of sound sources (i.e., marine vessels only). Further, decommissioning activities are expected to be shorter in duration and involve a smaller fleet of marine vessels; therefore, the potential underwater sound impacts on marine mammals for decommissioning are expected to be no greater than those of SURF installation activities (Scenario 3).

The results presented in the tables below account for embedded controls for underwater sound management. Specifically, EEPGL will use the following embedded controls for the Project (see Section 2.14, Embedded Controls):

- Gradually increasing intensity of seismic impulses to allow sensitive species to vacate the area before injury occurs (i.e., soft starts), use of PSOs during VSP, and implementation of other measures recommended by the Joint Nature Conservation Committee (JNCC) guidelines (JNCC 2017), as applicable; and
- Maintaining equipment, marine vessels, and helicopters in good working order and operating them in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, to limit sound levels to the extent reasonably practicable.

Table 7.5-8: Modeled Horizontal Distances to Below PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans and Mid-Frequency Cetaceans: Scenario 1—FPSO Operations

Marine Mammal Hearing Group	Injury Criteria and Distances to Criteria Levels					
	Southall et al. (2007)			Finneran (2015)		
	Threshold (M-weighted) (SEL_{24h}; dB re 1 $\mu Pa^2.s$)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 $\mu Pa^2.s$)	R_{max} (m)	$R_{95\%}$ (m)
Non-impulsive sources (marine vessels)						
Low-frequency cetaceans	215	6	6	207	<5	<5
Mid-frequency cetaceans	215	<5	<5	199	<5	<5

Source: JASCO 2016

µPa = microPascal; dB = decibel; m = meter; s = second; SEL_{24h} = 24-hour sound exposure level

Table 7.5-9: Modeled Horizontal Distances to Below PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans and Mid-Frequency Cetaceans: Scenario 2—Installation of the FPSO Vessel, Including Mooring the FPSO and Using Several Construction and Service Vessels

Marine Mammal Hearing Group	Injury Criteria and Distances to Criteria Levels					
	Southall et al. (2007)			Finneran (2015)		
	Threshold (M-weighted) (SEL_{24h}; dB re 1 $\mu Pa^2.s$)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 $\mu Pa^2.s$)	R_{max} (m)	$R_{95\%}$ (m)
Low-frequency cetaceans	215	<5	<5	207	<5	<5
Mid-frequency cetaceans	215	—	—	199	—	—

Source: JASCO 2016

µPa = microPascal; dB = decibel; m = meter; s = second; SEL_{24h} = 24-hour sound exposure level
"—" = predicted sound levels at all locations are below injury criteria.

Table 7.5-10: Modeled Horizontal Distances to Below PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans and Mid-Frequency Cetaceans: Scenario 3—Installation of a Drill Center, Including Operation of a Drill Ship and a Pipelaying Vessel

Marine Mammal Hearing Group	Injury Criteria and Distances to Criteria Levels					
	Southall et al. (2007)			Finneran (2015)		
	Threshold (M-weighted) (SEL_{24h}; dB re 1 $\mu Pa^2.s$)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 $\mu Pa^2.s$)	R_{max} (m)	$R_{95\%}$ (m)
Non-impulsive sources (marine vessels)						
Low-frequency cetaceans	215	9	9	207	6	6
Mid-frequency cetaceans	215	<5	<5	199	--	--

Source: JASCO 2016

µPa = microPascal; dB = decibel; m = meter; s = second; SEL_{24h} = 24-hour sound exposure level

Table 7.5-11: Modeled Horizontal Distances to Below PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans and Mid-Frequency Cetaceans: Scenario 4—Completion of a Vertical Seismic Profile

Marine Mammal Hearing Group	Injury Criteria and Distances to Criteria Levels					
	Southall et al. (2007)			Finneran (2015)		
	Threshold (M-weighted) (SEL_{24h}; dB re 1 $\mu Pa^2.s$)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 $\mu Pa^2.s$)	R_{max} (m)	$R_{95\%}$ (m)
Low-frequency cetaceans	198	73	68	192	39	36
Mid-frequency cetaceans	198	35	32	187	--	--

Source: JASCO 2016

µPa = microPascal; dB = decibel; m = meter; s = second; SEL_{24h} = 24-hour sound exposure level

The results for the four scenarios are discussed below. It is important to note these results assume the sources are stationary for 24 hours, and that marine mammals will remain within the stated distance for the entire accumulation period (24 hours). This adds an element of conservatism to the assessment because it is unlikely any marine mammal would stay within the modeled injury zone for the entire 24-hour duration, and the thresholds are based on a 24-hour exposure period.

Scenario 1—FPSO Operation

Modeling predicted that non-impulsive underwater sound for Scenario 1 would attenuate to below PTS onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 6 meters (19.7 feet) and less than 5 meters (16.4 feet), respectively (based on the more conservative injury criteria for the marine mammal hearing groups).

Scenario 2—Marine Vessels during FPSO Installation

Modeling predicted that non-impulsive underwater sound for Scenario 2 would attenuate to below PTS onset acoustic thresholds for LFCs at a maximum horizontal distance of less than 5 meters (16.4 feet) (based on the more conservative injury criteria for the marine mammal

hearing group). Modeling predicted that MFCs would not be impacted at any distance under this scenario because the predicted underwater sound in the mid-frequency range would be below PTS onset acoustic thresholds at all locations.

Scenario 3—Marine Vessels (Drill Ship, SURF installation vessels)

Modeling predicted that non-impulsive underwater sound for Scenario 3 would attenuate to below PTS onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 9 meters (29.5 feet) and less than 5 meters (16.4 feet), respectively (based on the more conservative injury criteria for the marine mammal hearing groups).

Scenario 4—Vertical Seismic Profile

Modeling predicted that impulsive underwater sound from the VSP for Scenario 4 would attenuate to below PTS onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 73 meters (240 feet) and 35 meters (115 feet), respectively (based on the more conservative injury criteria for the marine mammal hearing groups).

Summary of Potential for Injury Due to Underwater Sound

With respect to acoustic injury thresholds, modeling results indicate the maximum distances from Project underwater sound sources to injury thresholds for both LFCs and MFCs are greatest for VSP, although the area within which injury could potentially occur would be much smaller for MFCs as compared to the potential area for LFCs.

Neither group of marine mammals would be expected to experience a negative impact at the population level. Some MFC species such as sperm whales dive much deeper than LFC species (approximately 1,200 meters [approximately 3,900 feet] in tropical and subtropical latitudes) (Mate undated; Amano and Yoshioki 2003; Watwood et al. 2006). Based on the highest R_{max} values from Table 7.5-11 (73 and 35 meters [293.5 and 114.8 feet] for LFCs and MFCs, respectively) and the depth of the water within the PDA (approximately 1,690 to 1,910 meters [5,544.6 to 6,266.4 feet]), neither the MFCs nor LFCs would be expected to dive deep enough that they could potentially be exposed to sound levels within the PDA that would cause injury or harm. Even if an individual or an MFC species were to dive to a sufficient depth to encounter the acoustic injury threshold, it would be physiologically unable to remain at these depths for a sufficient duration to cause injury (because the injury thresholds used in JASCO's model are predicated on 24 hours of continuous exposure).

PTS (were it to occur) would be irreversible by definition, but given the depth of the water in the PDA and the physiological limitations that would prevent marine mammals from diving deep enough and for a long enough period of time to experience PTS, the Project is not expected to cause PTS in marine mammals.

Magnitude of Impacts—Potential Injury Due to Underwater Sound

Potential injury-related impacts, if it were to occur, would be limited to the PDA, so the geographic extent is considered to be the **Direct AOI**. The potential for acoustic injury impacts

on marine mammals is limited primarily to VSP activities, which will be **Episodic** in nature and **Medium-term** (as they would occur in aggregate more than a week but less than a year). The intensity of potential acoustic injury impacts is considered **Negligible**, based on the following considerations:

- The potential for marine mammals to be exposed to sufficient sound levels and associated duration to cause injury is extremely small due to the depths at which the sound above the injury threshold will occur. Most of the marine mammals expected to be present in the PDA do not dive to the depths that will be required or, if they do (such as occasional deep diving by sperm whales), they do not remain submerged at these depths for sufficient time to experience acoustic injuries.
- EEPGL has committed to use suction piles to install the FPSO mooring spread and the SURF foundations.
- EEPGL has committed to using PSOs and soft-start procedures for VSPs in accordance with JNCC (2017) guidelines.
- If an individual mammal were to approach an operating VSP, they would experience disturbance prior to being exposed to sound levels above injury thresholds, and would likely divert away from the sound source.

This results in a magnitude rating of **Negligible** for potential acoustic injury impacts to marine mammals, as summarized in Table 7.5-12.

Disturbance from Anthropogenic Underwater Sound

Anthropogenic sounds below acoustic injury thresholds have the potential to mask relevant or naturally occurring sounds in the animals' environment. Masking can occur from natural and anthropogenic sounds (Hildebrand 2005) and can cause behavioral changes that can have ecological consequences for marine mammals. These may include changes in biologically important behaviors (e.g., breeding, calving, feeding, or resting), diving behavior (e.g., reduced or prolonged dive times, increased time at the surface, or changes in swimming speed), and historical migration routes (NOAA undated).

Although the above changes could occur in the PDA as a result of Project-generated sound, findings from U.S. territorial waters suggest that the population-level significance of disturbance from impulsive sound over a small area such as the PDA will likely be minor and temporary. The U.S. National Marine Fisheries Service reported that

> "…available data do not indicate that sound and disturbance from oil and gas exploration and development activities since the mid-1970s had lasting population level adverse impacts on bowhead whales. Data indicate that bowhead whales are robust, increasing in abundance, and have been approaching (or have reached) the lower limit of their historic population size at the same time that oil and gas exploration activities have been occurring in the Beaufort Sea and, to a lesser extent, the Chukchi Sea." (MMS and NOAA 2007)

The U.S. Bureau of Ocean Energy Management also reported that despite more than 50 years of oil and gas exploration and development in the Gulf of Mexico, there are no data to suggest these activities are significantly impacting marine mammal populations (BOEM 2014). Furthermore, the PDA is not known to be an important feeding, breeding, or calving area for marine mammals. It is highly likely individual animals would divert around an operating VSP to avoid Project-generated sound, but no significant impacts on life functions or potential population-level implications from underwater sound are expected. However, the potential extent for disturbance impacts will be larger than the extent for potential injury effects (although still expected to be limited to the Direct AOI).

Magnitude of Impacts—Potential Disturbance Due to Underwater Sound

Potential disturbance-level impacts could extend outside of the Direct AOI via sound propagation, so the geographic extent for this potential impact is considered to be the **Direct AOI + Central Stabroek Block**. The potential for acoustic disturbance impacts on marine is considered **Episodic** for impulsive sound activities (VSP) and **Continuous** for non-impulsive activities (e.g., vessel operations, FPSO operation). Disturbance-level impacts would be present on a **Medium-term** basis for impulsive activities and non-impulsive activities during decommissioning and on a **Long-term** basis for non-impulsive activities for drilling and installation and production operations. The intensity of potential disturbance-level sound impacts is considered to be **Medium** for impulsive sound impacts and **Negligible** to **Low** for non-impulsive sound impacts (based on the duration of the effect and the distance to which the effects could extend). This results in magnitude ratings of **Medium** for impulsive sound impacts and **Negligible** to **Small** for non-impulsive sound impacts, as summarized in Table 7.5-12.

Table 7.5-12: Magnitude Ratings for Impacts on Marine Mammals from Underwater Sound

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Development Well Drilling SURF Installation	Injury from sound exposure	Direct AOI + Central Stabroek Block	Negligible	Episodic	Medium-term	Negligible
Development Well Drilling (impulsive sound activities) SURF Installation (impulsive sound activities)	Disturbance from sound exposure	Direct AOI + Central Stabroek Block	Medium	Episodic	Medium-term	Small
Development Well Drilling and SURF installation (non-impulsive sound activities	Disturbance from sound exposure	Direct AOI + Central Stabroek Block	Low	Continuous	Long-term	Small

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
from marine vessel operations)						
Production operations (non-impulsive sound activities from marine vessel operations and FPSO operations)	Disturbance from sound exposure	Direct AOI + Central Stabroek Block	Low	Continuous	Long-term	Small
Decommissioning (non-impulsive sound activities from marine vessel operations)	Disturbance from sound exposure	Direct AOI + Central Stabroek Block	Negligible	Continuous	Medium-term	Negligible

Impact Significance— Potential Injury or Disturbance Due to Underwater Sound

Based on the magnitude of impact and receptor sensitivity ratings described above, the pre-mitigation significance rating for potential acoustic injury impacts on marine mammals is **Negligible**, and the pre-mitigation significance rating for potential sound-related disturbance impacts ranges from **Negligible** to **Moderate**.

7.5.3.4. Characterization of Impacts—Exposure to Permitted Discharges

Magnitude of Impact—Exposure to Permitted Discharges

The Project will involve routine, permitted discharges of waste streams to the sea. These discharges will begin during the development well drilling and FPSO/SURF installation stages and continue through the production operations stage and into the decommissioning stage. As described in Chapter 2, Description of the Project, and Section 6.4.3, Impact Assessment—Marine Water Quality, these discharges will be treated (as needed) in accordance with industry guidelines. Furthermore, marine mammals will be transient in the PDA and the duration of their exposure to any discharges will be very limited. Any potential impacts would be expected to be acute and recovery would be expected to occur quickly after the affected individual(s) exit the mixing zone. As such, the intensity of potential impacts on marine mammals from exposure to permitted discharges is considered **Negligible.** Impacts would occur within the **Direct AOI** (PDA) and would be **Continuous** and **Long-term**. Accordingly, the magnitude of impact is **Negligible** (Table 7.5-13).

Table 7.5-13: Magnitude Ratings for Potential Impacts from Permitted Discharges on Marine Mammals

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
All Project Stages	Exposures to permitted discharges	Direct AOI	Negligible	Continuous	Long-term	Negligible

Impact Significance—Exposure to Permitted Discharges

Based on the magnitude of impact and receptor sensitivity ratings described above, the pre-mitigation significance rating for potential toxicological effects on marine mammals from exposure to permitted discharges is **Negligible**.

7.5.3.5. Characterization of Impacts—Artificial Lighting

Artificial lighting is not known to directly attract or disturb marine mammals, so any potential impacts of artificial light on marine mammals are likely to be indirectly caused by a potential change in prey distribution. Fish and squid are known to be attracted to artificial light, and even plankton are sometimes capable of weak volitional movement through the water column in response to changing ambient light levels. Small fish, squid, and/or plankton make up a substantial part of most marine mammals' diets, so to the extent that Project vessels and the FPSO could facilitate the concentration of plankton and/or small fish and squid at the surface or around the vessels or FPSO, food density would increase and marine mammals may be attracted to the vessels to feed more efficiently. This impact is expected to be limited to only the immediate vicinity of the vessels and therefore only have a small influence on forage availability. This impact is thus rated as **Positive**, due to the potential for attracting food sources and the lack of documented adverse effects on marine mammals from artificial lighting.

7.5.4. Management Measures—Marine Mammals

The embedded controls integrated into the Project design and operational procedures constitute the practicable best management measures that are available to reduce the significance of potential impacts on marine mammals. Table 7.5-14 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 7.5-14: List of Embedded Controls and Monitoring Measures

Embedded Controls
When non-aqueous drilling fluid (NADF) is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.
Employ trained PSOs during the conduct of seismic-related activities.
Conduct a continuous observation of a mitigation zone (500 meters [1,640 feet] around the sound source) to verify whether it is clear of marine mammals and marine turtles before commencing sound producing seismic operations. Do not commence sound-producing seismic operations (including soft

starts) if marine mammals or turtles are sighted within the mitigation zone during the 30 minutes prior to commencing sound-producing operations in water depths less than 200 meters (656 feet), or 60 minutes prior to commencing sound-producing operations in water depths greater than 200 meters (656 feet).
Where reasonably practicable, equip sound-making devices or equipment with silencers or mufflers that are enclosed, and/or use soft-start procedures (e.g., for vertical seismic profiling) to reduce noise to levels that do not cause material harm or injury to marine species
Adhere to the JNCC guidelines (2017) during the conduct of seismic-related activities.
For all effluent discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage), comply with International Maritime Organization / International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 milligrams per liter (mg/L) on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored, and the discharge meets the noted specification.
Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C (5.4°F) at 100 meters (approximately 328 feet) from discharge point.
Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals
Monitor residual chlorine concentration of sewage discharges from the FPSO monthly to stay below 0.5 mg/L in accordance with MARPOL 73/78 regulations.
Perform daily visual inspections on the FPSO of discharge points to verify that there are no floating solids or discoloration of the surrounding waters.
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.
Implement chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances and consider the Offshore Chemical Notification Scheme as a resource for chemical selection in Project production operations. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes; • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.
For effluent released from the onboard sewage treatment plant, comply with aquatic discharge standards in accordance with MARPOL 73/78 regulations.
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter particle size or less) prior to discharge.
Confirm there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge.
Treat bilge water in accordance with MARPOL 73/78 to comply with an oil-in-water content of less than 15 parts per million (ppm), as applicable. Perform oil in water content (automatic) monitoring of bilge water to verify compliance with 15 ppm MARPOL 73/78 limit and record in Oil Record Book.

Mitigation Measures
Following start-up of production operations, implement a program to characterize effluent water discharges from the FPSO and conduct an environmental risk assessment based on the characterization data. As appropriate based on the results of the environmental risk assessment, implement additional treatment options, if warranted and feasible.
Monitoring Measures
Continue to monitor marine mammals, riverine mammals, and marine turtles on the basis of incidental detections by MMOs and passive acoustic monitoring during seismic exploration activities.
Prior to and post-drilling, a remotely operated vehicle will take pictures of the area immediately surrounding the well location to monitor for marine water quality impacts.
Monitor daily during drilling to confirm that end of well maximum weighted mass ratio averaged over all well sections drilled using non-aqueous base fluid shall not exceed 6.9 percent wet weight base fluid retained on cuttings.
Monitor daily produced water discharge volume.
Measure oil and grease content of produced water (grab sample once per day).
Perform daily inspections to verify no visible sheen from discharge of cooling water.
Monitor temperature of FPSO cooling water discharges and produced water to avoid increases in ambient water temperature of more than 3°C (5.4°F) at 100 meters (approximately 328 feet) from point of discharge.
Use a load-monitoring system in the FPSO control room to support FPSO offloading.
Monitor pressure and temperature of subsea wells and manifolds by a control system on the FPSO to detect and prevent leaks.
Monitor residual chlorine concentration of treated sewage discharges from the FPSO monthly to stay below 0.5 mg/L in accordance with MARPOL 73/78 regulations.
Perform daily visual inspection of discharge points to verify that there are no floating solids or discoloration of the surrounding waters.
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book.
Perform oil-in-water content (automatic) monitoring of bilge water to comply with 15 ppm MARPOL 73/78 limit and record in Oil Record Book.
Record estimated volume of ballast water discharged and location (per ballasting operation).

Table 7.5-15 summarizes the assessment of potential pre-mitigation and residual Project impacts on marine mammals. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, as well as the marine mammals-specific methodology described in Sections 7.5.3.2 and 7.5.3.3.

Table 7.5-15: Marine Mammals—Pre-Mitigation and Residual Impact Significance Ratings

Stage	Potential Impact	Magnitude Rating	Sensitivity Rating	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Well Drilling FPSO/SURF Installation, Commissioning, and Start-up	Injury from sound exposure	Negligible	Medium	Negligible	None, other than implementation of embedded controls (e.g., soft-start procedures for VSP)	Negligible
Development Well Drilling (impulsive sound activities) SURF Installation (impulsive sound activities)	Disturbance from sound exposure	Small	Medium	Minor	None, other than implementation of embedded controls (e.g., soft-start procedures for VSP)	Minor
Development Well Drilling (non-impulsive sound activities) from marine vessel operations	Disturbance from sound exposure	Small	Medium	Minor	None	Minor
Production operations (non-impulsive sound activities) from operating FPSO and marine vessel operations	Disturbance from sound exposure	Small	Medium	Minor	None	Minor
Decommissioning (non-impulsive sound activities) from marine vessel operations	Disturbance from sound exposure	Negligible	Medium	Negligible	None	Negligible
All Project Stages	Exposures to permitted discharges (liquid effluent discharges containing various chemical substances, plus elevated temperature	Negligible	Medium	Negligible	None	Negligible

Stage	Potential Impact	Magnitude Rating	Sensitivity Rating	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
	during production operations)					
	Offshore lighting as an attractant of food sources for marine mammals	Positive	Medium	Positive	None	Positive

7.6. RIVERINE MAMMALS

7.6.1. Administrative Framework—Riverine Mammals

Table 7.6-1 summarizes the legislation, policies, or treaty commitments that are specifically relevant to the assessment of potential impacts on riverine mammals.

Table 7.6-1: Legislation, Policies, or Treaty Commitments—Riverine Mammals

Title	Objective	Relevance to the Project
Legislation		
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013; the Wild Birds Protection Act, 1987; and the Species Protection Regulations, 1999)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a framework to address the national goals for wildlife protection, conservation, and management. The Act also provides recommendations on measures for the protection of threatened ecosystems and habitats, and advises on measures for conservation of biological diversity.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity (Guyana signed in 1992 and ratified in 1994)	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Encourages Project design and execution to protect and conserve biological diversity.
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (Guyana acceded and ratified in 2010)	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection of the marine environment, especially from possible pollution.

7.6.2. Existing Conditions—Riverine Mammals

Riverine mammals are aquatic mammals that live in inland and coastal riverine and wetland environments. Many riverine mammal species also spend time in nearshore marine environments, so they have a wide range of salinity tolerance, frequenting freshwater, estuarine, and marine environments. The distribution and composition of riverine mammals in Guyana is largely unknown, and no known systematic survey of riverine mammals has been conducted in the country. Riverine mammals known to occur in Guyana include American manatee (*Trichechus manatus*), giant otter (*Pteronura brasiliensis*), neotropical otter (*Lontra longicaudis*), and Guiana dolphin (*Sotalia guianensis*). Tucuxi (*Sotalia fluviatilis*) and Amazon River dolphin (*Inia geoffrensis*) may also occur infrequently in southern Guyana when seasonal rains connect the Amazon and Essequibo rivers via the Rupununi wetlands, but neither species is expected to be encountered in or near the area of Project activities. Table 7.6-2 lists these species along

with their IUCN Red List classification (IUCN 2021) and their habitat preferences. The Guiana dolphin is predominantly an estuarine and coastal species. All other species described in this section mainly occur in freshwater, but can also occur in coastal and nearshore marine habitats, as confirmed by a survey of nearshore Guyana waters conducted by Charles et al. (2004) of 125 Guyanese captains of trawl, drift seine, and red snapper fishing vessels. As discussed in Section 7.5, Marine Mammals, numerous other species of marine mammals (particularly dolphins) occasionally occur in riverine habitats of Guyana, but since these species are primarily associated with marine habitats they are not discussed further in this section.

Table 7.6-2: Riverine Mammals of Guyana

Common Name	Scientific Name	IUCN Status	Habitat Preferences
American manatee	*Trichechus manatus*	VU	Inhabits rivers, lakes, coastal and inland lagoons, and coastal marine environments, including seagrass, mangrove, and coral reef ecosystems (Deutsch et al. 2008).
Giant otter	*Pteronura brasiliensis*	EN	Inhabits large, slow-moving inland freshwater rivers, streams, lakes, and swamps that possess high fish densities. May occur in agricultural canals, reservoirs, and drainage channels along roads (Groenendijk et al. 2015).
Neotropical otter	*Lontra longicaudis*	NT	Occurs in a large variety of habitats, from rocky shorelines to deciduous and evergreen forests, warm and cool climate rainforests, and coastal savanna swamps. Occurs in both fresh and saline environments, including areas with high levels of human influences such as agricultural areas and pastures (Rheingantz and Trinca 2015).
Guiana dolphin	*Sotalia guianensis*	NT	Inhabits coastal and estuarine habitats across Central and South America in the Caribbean and Atlantic Oceans. This species is concentrated in tropical and subtropical shallow and coastal waters of the continental shelf (de Jesus Lobo et al. 2021).
Tucuxi	*Sotalia fluviatilis*	EN	Inhabits the inland freshwaters of the white, clear, and black waters of the Amazonian rivers. Display a preference for the junctions of rivers and channels. The most preferred habitat is where a sediment-rich white-water channel meets low pH black water (Martin et al. 2004). Not expected to occur within or near Project activities.
Amazon River dolphin	*Inia geoffrensis*	EN	Inhabits the inland freshwaters of the Amazon and Orinoco rivers. Sexual segregation is common: females with dependent calves spend more time inside the flooded forest and in lakes and small tributaries during the rainy season, while most adult males spend most of their time in the main rivers. During the dry season, this species is often concentrated below channel confluences (da Silva et al. 2018). Not expected to occur in or near the area of Project activities.

Source: IUCN 2021

EN = Endangered; NT = Near Threatened; VU = Vulnerable

7.6.2.1. Regional Setting and Species Descriptions

The riverine mammals of Guyana occupy a wide variety of inland and coastal habitats, including inland rivers and wetlands and coastal and nearshore marine waters. These habitats are by extension interconnected with similar habitats of the Amazon River in Brazil and the Orinoco River delta in Venezuela via the Amazonian-Orinoco Influence Zone and the Rupununi portal. The Amazonian-Orinoco Influence Zone is an Ecologically or Biologically Significant Area (EBSA) that encompasses the offshore waters of eastern Trinidad, Guyana, Suriname, French Guiana, and northern Brazil, and borders the shoreline from the Orinoco River in the north to the Amazon River in the south (Secretariat of the Convention on Biological Diversity 2014). This EBSA's uniqueness and biological productivity are driven largely by the influence of freshwater inputs from the Amazon River and the nutrients it carries, which extend north and west across the coast of northern South America to the Orinoco River delta in Venezuela. The Rupununi portal is a unique hydrogeographic feature that allows for a seasonal hydrological connection between the Essequibo River and the Amazon basin via the Rupununi savannas and wetlands (de Souza et al. 2020).

American Manatee

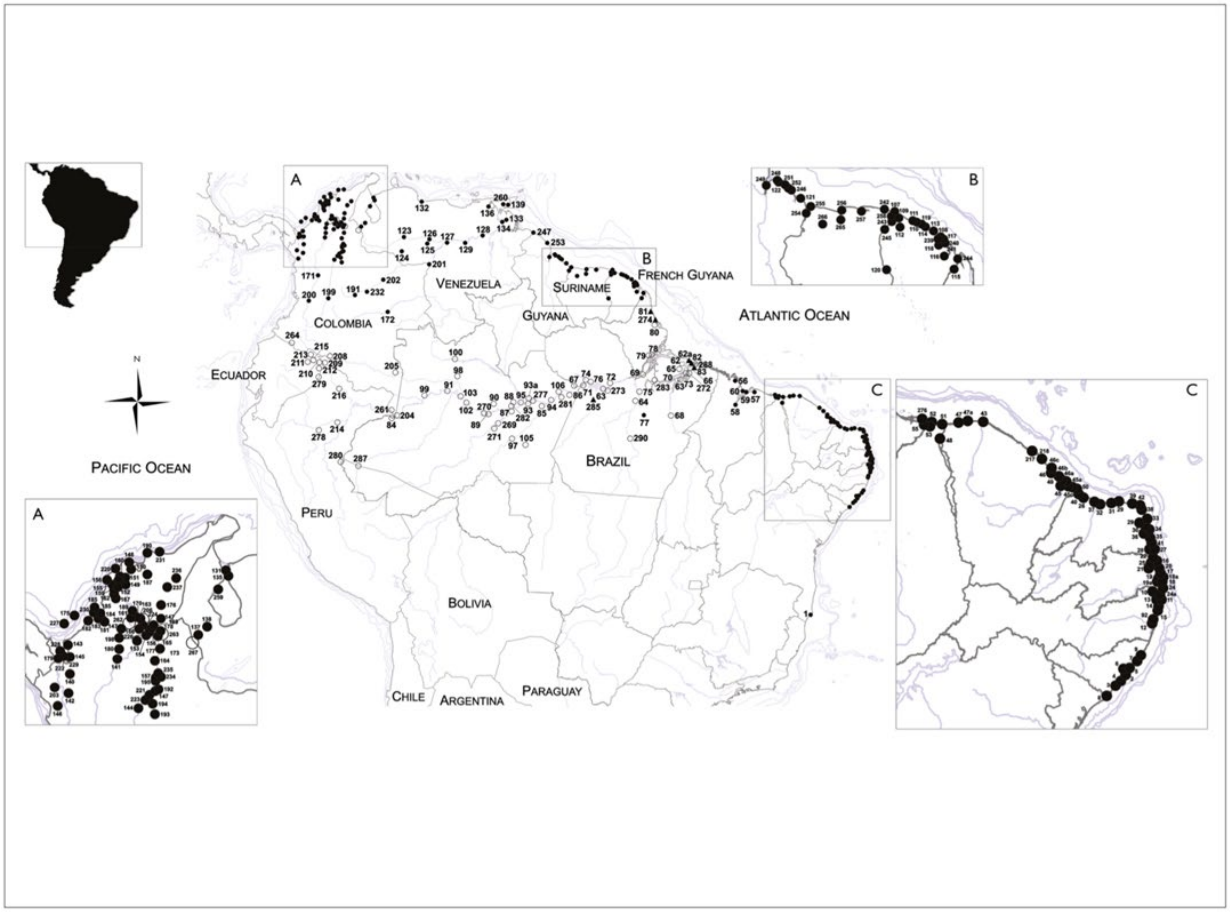
The American manatee is known to occur throughout the Gulf of Mexico and the Caribbean Sea. Two subspecies of the American manatee are currently recognized based on skull characteristics (Domning and Hayek 1986): the Antillean manatee (*T. manatus manatus*) and the Florida manatee (*T. manatus latirostris*). There is also a smaller species of manatee, *Trichechus inunguis*, landlocked in the Amazon basin, which may occasionally penetrate into southern Guyana close to the boundary with Brazil, but since this species is a rare transient species in southern Guyana, it is not discussed further herein. The two subspecies of American manatee are not easily distinguishable externally, but they occupy distinctively different geographic ranges. The range of the Florida manatee is limited to the southeastern United States. The Antillean manatee occurs throughout the Caribbean and the Northwestern Atlantic Ocean from Mexico, east to the Greater Antilles, and south to Brazil. The subspecies is extant or transient in 41 countries in the Caribbean region (Deutsch et al. 2008).

Throughout most of its range, the American manatee prefers the shallow waters of rivers and estuaries that contain aquatic vegetation. Early records from a study by Bertram and Bertram (1960) on the status of the American manatee in the Guianas revealed that in Guyana, manatees live mainly in the rivers of the coastal plain, particularly in the regions of wet savannah where suitable vegetation is available for food. Northwestern Guyana and the eastern region near the Suriname border support the greatest numbers of manatees in the country, but nowhere are they abundant. The study also documented that very little is known about the life history of manatees in the Guianas (UNEP 2010).

There have been no comprehensive population studies on manatees in Guyana over the past decade; the most recent population estimate was provided by UNEP (2010), which estimated approximately 100 individuals in Guyana with a declining population. Incidental captures of

manatees by fishermen from Canal #1 Demerara River and coastal areas of Lusignan and Buxton were relocated by the Guyana Wildlife Conservation and Management Commission (GWCMC) on several occasions in in recent years (2017 to 2019) (Cromwell L., *pers com*, GWCMC, 2021). All available sightings of manatees in South America are shown on Figure 7.6-1.

No recent systematic, range-wide survey or population estimate of American manatees, particularly the Antillean subpopulation, exists. However, in 2010 the previously cited UNEP study estimated the entire population of American manatee (including all subspecies) to be approximately 9,000 individuals. The IUCN estimates that fewer than 2,500 mature Antillean manatees currently exist, scattered widely through the Caribbean region (IUCN 2021). Geographic distribution is not continuous and local populations are patchy and fragmented.



Source: Bonvicino et al. 2020

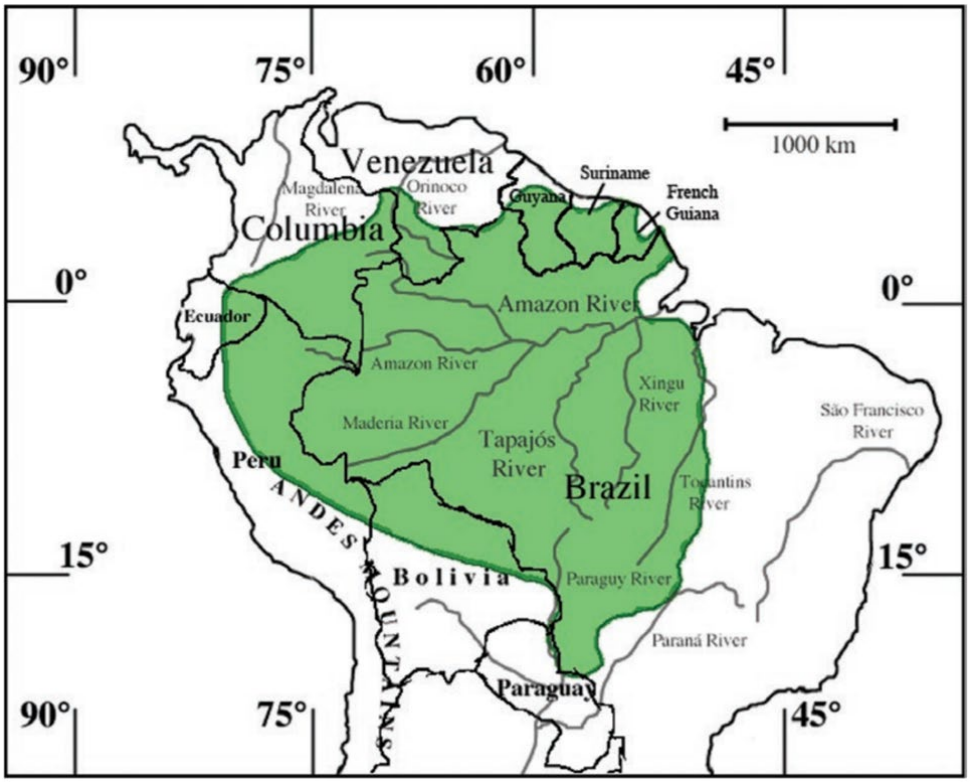
South America map showing all available records of manatees: A) detail of north Colombia and northwestern Venezuela; B) north of Guyana, Suriname, and French Guiana; C) northern Brazil. Black circles indicate *Trichechus manatus* localities, open circles *T. inunguis*, open square sympatry between them, and black triangles *Trichechus* sp. localities. Numbers refer to names of localities listed in Appendix 1 of Bonvino et al. 2020.

Figure 7.6-1: Concentration of Manatees along the South America Coastlines

IUCN lists the American manatee as Vulnerable because the number of mature individuals is currently estimated at less than 10,000 individuals based on combined population estimates for the Florida and Antillean subspecies. Total populations (including all subpopulations) are projected to decline by at least 20 percent over the next two generations (estimated at approximately 40 years) (IUCN 2021). The Antillean manatee is currently threatened by habitat degradation and loss, hunting, accidental fishing-related mortality, pollution, and human disturbance (IUCN 2021).

Giant Otter

The giant otter is endemic to South America and has been sighted from north to south-central South America, with stable populations limited to the Amazon basin and upper Pantanal in the Paraná-Paraguay river basin (Franco-de-Sa et al. 2007), as shown on Figure 7.6-2. Giant otters live on major river systems up to elevations of approximately 1,000 meters (3,281 feet). Between 4,400 and 7,600 giant otters are estimated to occur in wild populations. Colombia, Guyana, and Suriname have the largest populations (Noonan et al. 2017). Although there are no current population estimates for giant otters in Guyana, they are known to range along river and lake systems (McTurk and Spelman 2005). In Guyana, they are most numerous in uninhabited areas, such as along the Rupununi River and its tributaries, where they are known as ‘‘water dogs’’ or “turara” in the Macusi language (McTurk and Spelman 2005).



Source: Noonan et al. 2017; as modified from the International Union for Conservation of Nature and Natural Resources (2015)

Figure 7.6-2: Geographic Distribution of Giant Otter *(Pteronura brasiliensis*)

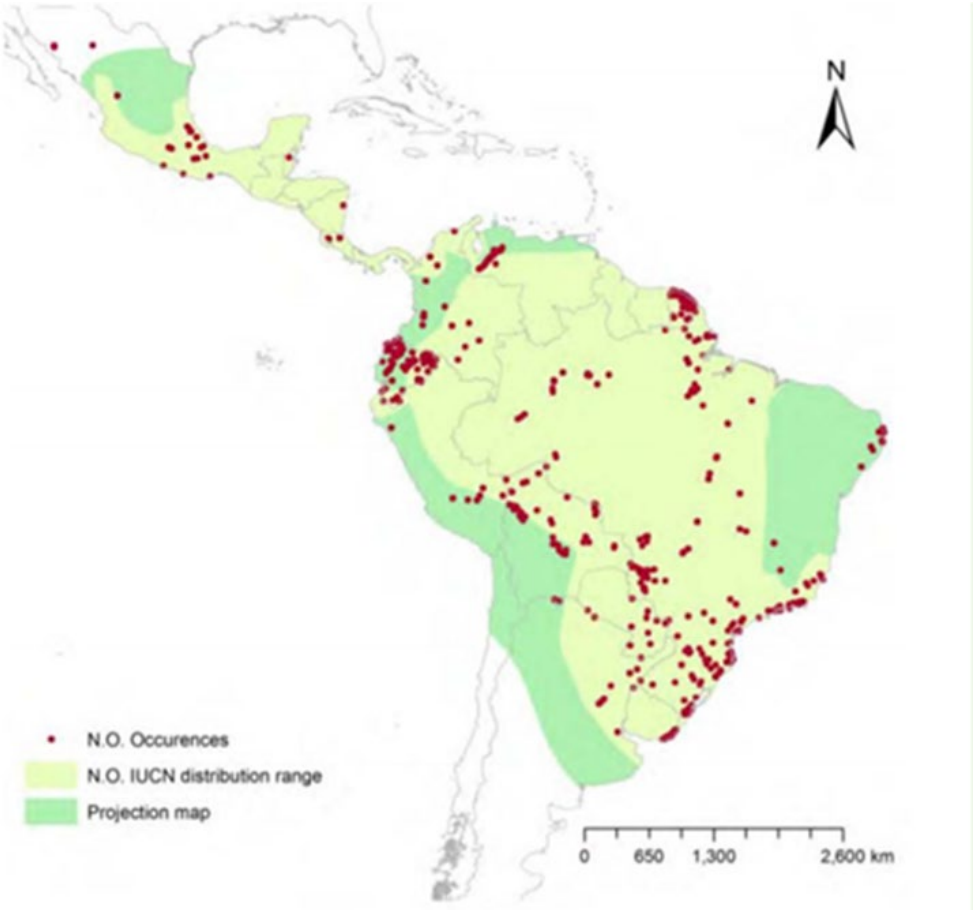
The giant otter prefers slow-moving water with an abundance of food and sloping banks with protective cover. Groups may remain in the same territory for 5 or more years but may abandon territories during the flooding season. In Guyana, these habitat conditions are met in the interior rivers, particularly the Rupununi River, where several family groups of giant otters reside (Duplaix 2004; Roopsind 2019). This species is primarily piscivorous particularly when dry conditions concentrate fish in small areas, but it will prey on crustaceans, mollusks, and terrestrial vertebrates on an opportunistic basis (Noonan et al. 2017).

Studies on the giant otter in Guyana's rivers by Laidler (1984) reported their presence near the coastal village of Morawhanna in the Barima River northwest Guyana, in the Mahaica River, and in the East Demerara Water Conservancy (one of Guyana's major water storage and flood control facilities) and its tidal creeks, including Lama Creek, Maduni Creek, and Carabice Creek. Other studies confirmed the presence of the species in the Mahaica River and also reported sightings of the species in the Abary River and in inland freshwater habitats of the Rupununi Savannah, the Potaro Plateau in western Guyana, and the Sipuruni River (Duplaix 2004; Melquist 1984).

No country-specific survey data exist for giant otter in Guyana; however, available data elsewhere in the species' range indicate that the global population size is low and decreasing due to habitat loss, habitat degradation, and other human activities. Moreover, most populations are isolated from each other, increasing local extinction risk. The giant otter is listed as Endangered (EN) by the IUCN based on low and decreasing population size combined with limited resilience to reductions in habitat quality, late maturity and breeding age, and suspected low adult and cub survival, all of which limit giant otter recovery and re-colonization (IUCN 2021). Historically, giant otters were hunted for their pelts. Today, they are primarily threatened by increased human settlement and activity throughout the species' range, which results in habitat loss and degradation, overfishing, introduction of diseases from domestic animals, and poaching. In the Guiana Shield region (Suriname, Guyana, French Guiana, Venezuela, and northern Brazil) and in southeastern Peru, gold mining is a significant threat to the species due to the resulting habitat loss and degraded water quality.

Neotropical Otter

The neotropical otter occurs from northwestern Mexico to Uruguay (Gallo 1991), Paraguay, and the northern part of Argentina to Buenos Aires province (Chehebar 1990; Cockrum 1964; Redford and Eisenberg 1992), as shown on Figure 7.6-3. The species occurs from sea level up to 4,000 meters (13,123 feet) above sea level (Muanis and Oliveira 2011). The species is found in both fresh and saline environments and occurs in a large variety of habitats, including rocky shorelines, deciduous and evergreen forests, warm and cool climate rainforests, and coastal savanna swamps (Emmons and Feer 1990, in Rheingantz and Trinca 2015). Preferred habitat conditions for this species include high-quality riparian cover (i.e., with dense, native vegetation) (Bertonatti and Parera 1994; Redford and Eisenberg 1992) and abundant potential den sites (Soldateli and Blacher 1996). In Guyana, they are known to occur in drainage ditches related to rice and sugar cane plantations (Larivière 1999), including the ditches and canals draining to the lower Demerara River.



Source: Rheingantz et al. 2014

Unique records (n=565) are in in red, overlaid with IUCN distribution in light green, and Maxent projection in green

Figure 7.6-3: Neotropical Otter (*Lontra longicaudis*) Unique Record Locations

The Amazon regions in Brazil, Guyana, Venezuela, and the Pantanal are suitable areas for the Neotropical otter due to their low human density, warm climate, and pristine habitats (Rheingantz et al. 2014). No range-wide estimates of abundance, trends in abundance, or survey data exist for neotropical otter in Guyana. Limited data throughout the species' range indicate a decreasing population trend. The species is listed as Near Threatened (NT) by the IUCN (Rheingantz and Trinca 2015). Historically, neotropical otters were hunted for their pelts to the point of localized extinction. Today they are still threatened by hunting, but also by habitat loss and degradation from deforestation, mining, and water pollution.

Guiana Dolphin

The Guiana dolphin occurs primarily in shallow waters near shore and in estuaries, bays, or other sheltered areas along the Atlantic coast of northern and eastern South America, though their presence has been reported 300 kilometers (186.4 miles) up river in the lower Orinoco River close to Ciudad Bolívar, Venezuela (Borobia et al. 1991; Boher et al. 1995; Trujillo et al. 2000). Guiana dolphins are reported to occur in the Demerara, Cuyuni, Mazaruni, and Essequibo River mouths (Williams et al. 2016; Herald 1967 as cited in da Silva Best 1994).

Guiana dolphins have patchy distribution (Borobia et al. 1991; Flores and da Silva 2009; Da Silva et al. 2010) and small home ranges, possibly extending only 10 to 15 kilometers (6.2 and 9.3 miles; Flores and Bazzalo 2004), and occur in groups of 1 to 40 individuals (Azevedo et al. 2007). The distribution of Guiana dolphin in near-shore areas indicates that some populations may be exposed to high levels of pollution from industrial and agricultural activities, including both indirectly by degradation of habitat and directly through contamination of prey (IUCN 2021). Artisanal fishing with gillnets and other gear are a known cause of incidental mortality throughout most the of the species' range, with high bycatch reported where monitoring has occurred. It is also known that some Guiana dolphins are killed intentionally to be used as shark bait (da Silva and Best 1994; IWC 2007; Flores and da Silva 2009). Offshore oil development in Brazil, Venezuela, and Colombia may not pose a direct threat to Guiana Dolphins; however, oil spills, particularly in estuaries, could affect local populations (da Silva and Best 1994; Culik 2004). In recent years, skin diseases have been observed on dolphins in estuaries (Van Bressem et al. 2009). Abundance estimates are not available for individual populations across their range (IUCN 2021), and historical estimates often conflict with later estimates made using more rigorous methods. The Guiana dolphin is listed as NT by IUCN (IUCN 2021) and is legally protected within most of its range.

Tucuxi

The freshwater dolphin tucuxi is found in the Amazon River drainage and has been reported to occur in the Orinoco River; however, no confirmed sightings or modern surveys have documented this species in Guyana, and the IUCN does not include Guyana or the neighboring coastal countries in their known range (IUCN 2021). There are no records of past or recent commercial fisheries for the species (IWC 2001). It is assumed dolphins cannot traverse the rapids at the Casiquiare Channel, which is the only possible point of contact with the Amazon River and connects the Orinoco and Amazon River basins (da Silva and Best 1996; Bangueria-Hinestroza et al. 2002). It is likely that historically unverified sightings of tucuxi were actually Guiana dolphin. The tucuxi is listed as EN by the IUCN (IUCN 2021). Tucuxi are threatened primarily by incidental mortality in fishing gear, deliberate killing for use as bait, damming of rivers, and environmental pollution from organochlorides and heavy metals (Best and da Silva 1989; Trujillo et al. 2010). Although tucuxi can hypothetically occur in Guyana, encounters with them are not expected in the riverine and coastal areas where Project-related activities will occur.

Amazon River Dolphin

Amazon River dolphin is the most widespread river dolphin, inhabiting rivers and lakes throughout the Amazon and Orinoco river basins in Brazil, Bolivia, Colombia, Ecuador, Peru, and Venezuela. The species may occur up to the Brazil border with Guyana (WWF Undated); however, IUCN does not include Guyana within its range. No survey data for the species in Guyana exists. Water level affects the use of habitat by Amazon River dolphins for all age classes; however, females with dependent calves spend more time inside interior flooded forests and in lakes and small tributaries during the rainy season, while most adult males spent

most of their time in the main rivers. During the dry season, this species is often concentrated below channel confluences (da Silva et al. 2018). The IUCN lists the Amazon River dolphin as EN (IUCN 2021). Amazon dolphins are threatened by similar activities as listed for the Guiana dolphin and the tucuxi. Populations in Brazil may suffer mortality from use of explosives as well as from oil spills occurring in Peru, northern Ecuador, and Venezuela; however, overall threats by oil and gas extraction remain low (WWF Undated). Although this species may occur within interior Guyana along the Brazil border, it is not expected to occur within or near the Project area.

7.6.2.2. Riverine Mammal Data for the Direct Area of Influence

EEPGL commissioned a targeted survey of riverine mammals in early 2019 in the area between the Demerara Harbour Bridge and the mouth of the Demerara River. The objective of the survey was to document the species assemblage and abundance of riverine mammals within the lower Demerara River between the Demerara Harbour Bridge and the mouth of the Demerara River, including the portion of the river around the shorebase facilities where Project-related vessel traffic and onshore infrastructure operations will occur. The survey was conducted 2 days per month during daylight hours from dawn to dusk (roughly 24 hours of survey time per month) using visual scans of the river's surface with the naked eye and with binoculars from a vessel.

The only riverine mammal detected during the study was American manatee. The survey covered three dry seasons and two intervening wet seasons between 2019 and 2020 and detected manatees on 13 occasions (Figure 7.6-4). Fourteen individuals were sighted during the entire study period. Nine of the 14 individuals sighted were sighted during dry season conditions. The remaining five individuals were sighted during wet season conditions, but when the number of sightings in each season was normalized for effort, the detection rates were only slightly higher during the dry season than during the wet season.

The observers documented a range of activities including courtship, diving, and directional swimming. Most manatee sightings were recorded close to the river banks outside of the ship channel. Of the 14 manatee sightings recorded, 9 occurred at the mouth of the river. This area may be favored by the manatees for feeding since submerged rocks covered in aquatic vegetation are found close to the riverbank in the area. In addition, vessel traffic was observed to be very low near the riverbank compared to further offshore in the main channel. The manatees may be using nearshore areas to avoid the busier parts of the river.

Tidal stage may also play a role in influencing detection rates. More sightings occurred during high-tide periods than during low tides. While additional surveys would be needed to properly establish the relationship between manatee activity and tide stage in the Demerara River, manatees are known to move elsewhere during high tide. Fish (1994) surmised that manatees might avoid ship channels during high discharge periods, particularly in large riverine-driven systems, because movement may be more difficult and energetically costly when the direction of flow opposes the direction of travel.

Figure 7.6-4: Location of Riverine Mammal Sightings Recorded During EEPGL-Commissioned Riverine Mammal Surveys

The information presented in this section was collected from relevant scientific literature and the largest collection of observational survey data for riverine mammals in the Demerara River to date. The study results described in this section corroborate prior expectations concerning where American manatees would be most likely to occur in the river based on expert knowledge of their habitat preferences and anecdotal information from other locations in the Caribbean region. For these reasons, the Consultants consider the information presented in this section adequate to support an assessment of likely Project impacts on riverine mammals.

7.6.3. Impact Assessment—Riverine Mammals

Of the five species of riverine mammals in Guyana, two species could have the reasonable possibility to interact with planned Project activities—the American manatee and the neotropical otter—as these species occur in in the brackish/intertidal waters of the Demerara Harbour where Project-related vessel traffic will occur. The other three species, the giant otter, tucuxi, and Amazon River dolphin, are freshwater species that are not likely to be encountered within areas affected by planned Project activities.

7.6.3.1. Relevant Project Activities and Potential Impacts

As shown in Table 7.6-3, the impact assessment considers the potential for planned Project activities to impact riverine mammals through temporary displacement (e.g., as a result of increased vessel traffic within the Demerara Harbour from Project activities). Impacts on riverine mammals related to unplanned events (e.g., vessel strike and oil spill) are discussed in Section 9.10, Riverine Mammals.

As described in Section 8.4, Marine Use and Transportation, the Project's marine activities will increase the existing marine traffic in Georgetown Harbour by 2 to 4 percent over existing conditions. Specifically, it is estimated that during development drilling and FPSO/SURF installation, installation and support vessels may make an average of approximately 12 to 15 round-trips per week between the Stabroek Block and shorebases for the first 5 years of the Project. During the production operations stage, it is estimated that this number will be reduced to approximately three to five round-trips per week. These vessel round-trips will be loaded and offloaded at shorebase facilities in Guyana and/or Trinidad and Tobago. No seasonal differences in vessel traffic are anticipated.

Table 7.6-3: Summary of Relevant Project Activities and Key Potential Impacts—Riverine Mammals

Stage	Project Activity	Key Potential Impact
All Project stages	Onshore infrastructure operations; Project-related vessel operations	Behavioral changes or displacement of riverine mammals as a result of increased vessel traffic within Georgetown Harbour

7.6.3.2. Magnitude of Impacts—Riverine Mammals

The assessment of the Project's magnitude of potential impacts on riverine mammals is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on riverine mammals from Project-related vessel traffic is defined according to the definitions provided in Table 7.6-4. The following paragraphs discuss the characteristics of the potential impacts assessed and the resultant magnitude ratings. These are summarized in Table 7.6-5.

Table 7.6-4: Definitions for Intensity Ratings for Potential Impacts on Riverine Mammals

Criterion	Definition
Intensity	Negligible: No discernible change in riverine mammal behavior or presence in the impacted area.
	Low: Minor behavioral changes (temporary avoidance of impacted area) by riverine mammals that would not measurably impact habitat use, local population status, or viability of riverine mammal population.
	Medium: Observable changes in riverine mammal behavior (long-term avoidance or abandonment of previously occupied habitats) or low levels of injury or mortality that would not affect the long-term viability of the riverine mammal population.
	High: Significant changes in riverine mammal behavior (species eliminated from the impacted area) or significant mortality that could affect the long-term viability of the riverine mammal population.

Historical and ongoing human activities within Georgetown Harbour have substantially modified the primary ecological functions and species composition of habitats within the harbor, resulting in habitat loss and species displacement. Resident riverine mammals of the harbor are, therefore, habituated to the constantly changing and human-influenced environments of the harbor. Onshore infrastructure operations of the Project within the harbor will use existing shorebase support facilities and as such, onshore Project activities are predicted to have little to no impact on resident riverine mammals because they are already habituated to human activities and vessel traffic. The slight increase in overall marine vessel traffic in Georgetown Harbour that will occur as a result of the Project may result in a slight incremental increase in temporary avoidance behavior and displacement from the vessel transport route, which itself represents a small portion of the available riverine habitat within the harbor. It is expected that resident riverine mammals will move away (or have already moved away based on the pre-existing history of marine vessel activity) to areas of the harbor with lower vessel traffic. As such, the intensity of the potential impacts on riverine mammals is rated as **Low**.

Project-related marine traffic will occur on a routine basis and continue throughout the Project life cycle (at least 20 years), yielding a frequency designation of **Continuous** for all stages. The duration of Project-related impacts on riverine mammals will be **Long-term** for drilling, installation, and production operations phases, and at least **Medium-term** for the decommissioning stage. This yields a magnitude rating of **Small** for potential impacts on riverine mammals from Project-related marine traffic.

Table 7.6-5: Magnitude of Impact—Riverine Mammals

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Development Well Drilling SURF/FPSO Installation Production Operations	Behavioral changes or displacement of riverine mammals as a result of increased vessel traffic within Georgetown Harbour	Direct AOI (Georgetown Harbour)	Low	Continuous	Long-term	Small
Decommissioning	Behavioral changes or displacement of riverine mammals as a result of increased vessel traffic within Georgetown Harbour	Direct AOI (Georgetown Harbour)	Low	Continuous	Medium-term	Small

7.6.3.3. Sensitivity of Receptors—Riverine Mammals

Of the two riverine mammals likely to be encountered within Georgetown Harbour (American manatee and the neotropical otter, as described in Section 7.6.2, Existing Conditions—Riverine Mammals), the American manatee has the highest threat level, listed as Vulnerable by the IUCN, and as such the assessment of impacts on riverine mammals was conducted based on the conservative assumption that this species would be the receptor for potential impacts. Consistent with the receptor sensitivity ratings used for the assessment of potential impacts on special status species, as defined in Table 7.6-6, riverine mammals are considered to have a **Medium** sensitivity.

Table 7.6-6: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Special Status Species (Adopted for Potential Impacts on Riverine Mammals)

Criterion	Definition
Sensitivity	Negligible: Species with no specific value or importance attached to them.
	Low: Species and sub-species of Least Concern on the IUCN Red List (or not meeting criteria for medium or high value), or without specific anatomical, behavioral, or ecological susceptibilities to potential Project-related impacts.
	Medium: Species listed as Vulnerable, Near Threatened, or Data Deficient on the IUCN Red List; species protected under national legislation; nationally restricted range species; nationally important numbers of migratory or congregatory species; species not meeting criteria for high value; and species vital to the survival of a medium value species.
	High: Species on IUCN Red List as Critically Endangered or Endangered. Species having a globally restricted range (i.e., endemic species to a site, or found globally at fewer than 10 sites, fauna having a distribution range less than 50,000 square kilometers [19,305 square miles]), internationally important numbers of migratory or congregatory species, key evolutionary species, and species vital to the survival of high value species.

7.6.3.4. Impact Significance—Riverine Mammals

Based on the magnitude of impact and receptor sensitivity ratings described above, the significance ratings for potential impacts on riverine mammals is **Minor**.

7.6.4. Management Measures—Riverine Mammals

The embedded controls integrated into the Project design and operational procedures constitute the practicable best management measures that are available to reduce the significance of potential impacts on riverine mammals. Table 7.6-7 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 7.6-7: List of Embedded Controls and Monitoring Measures

Embedded Controls
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.
Monitoring Measures
Continue to monitor marine mammals, riverine mammals, and marine turtles on the basis of incidental detections by MMOs and passive acoustic monitoring during seismic exploration activities.

Table 7.6-8 summarizes the assessment of potential pre-mitigation and residual Project impacts on riverine mammals.

Table 7.6-8: Summary of Potential Pre-Mitigation and Residual Impacts—Riverine Mammals

Stage	Potential Impact	Magnitude Rating	Sensitivity Rating	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project Stages	Behavioral changes or displacement of riverine mammals as a result of increased vessel traffic within Georgetown Harbour	Small	Medium	Minor	None	Minor

7.7. MARINE TURTLES

7.7.1. Administrative Framework—Marine Turtles

Table 7.7-1 summarizes the legislation, policies, or treaty commitments that are specifically relevant to the assessment of potential impacts on marine turtles.

Table 7.7-1: Legislation, Policies, or Treaty Commitments—Marine Turtles

Title	Objective	Relevance to the Project
Legislation		
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013; the Wild Birds Protection Act, 1987; and the Species Protection Regulations, 1999)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a framework to address the national goals for wildlife protection, conservation, management. The Act also provides recommendations on measures for the protection of threatened ecosystems and habitats, and advises on measures for conservation of biological diversity.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity (Signed in 1992, ratified in 1994)	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Encourages Project design and execution so as to protect and conserve biological diversity.
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (Guyana acceded and ratified in 2010)	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection of the marine environment, especially from possible pollution. Guyana acceded and ratified in 2010.
Protocol on Specially Protected Areas and Wildlife (Acceded and Ratified in 2010)	Protocol supplementing and supporting the Cartagena Convention. Requires signatories to adopt an ecosystem approach to conservation. Provides mechanism for compliance with the Convention on Biological Diversity.	Elaborates on the wildlife goals established in the Cartagena Convention and Convention on Biological Diversity.
International Maritime Organization Agreements (IMO)	The IMO administers a number of global environmental conventions, agreements, and commitments such as International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978, on ship-generated wastes; Ballast Water Convention; London Convention.	Contracting parties to the convention are also required to protect and preserve rare or fragile ecosystems and habitats of depleted, threatened, or endangered species; and develop technical and other guidelines for the planning and environmental impact assessments of important development projects.

7.7.2. Existing Conditions—Marine Turtles

According to the *Regional Sea Turtle Conservation Program and Action Plan for the Guianas* (Reichart et al. 2003) and Dow et al. (2007), marine turtles are an important natural resource shared by various countries throughout the Caribbean region and the Guiana Shield region, which includes Venezuela, Guyana, Suriname, French Guiana, and Brazil. The existing conditions for marine turtles in the Project AOI were described using observational data collected during various offshore exploration activities from 2015 to 2019, marine turtle telemetry studies conducted at Shell Beach (as described in Section 7.7.2.2, Marine Turtle Data Offshore Guyana, data from Reichart et al. (2003), and data compilations from Project GloBAL (2007).

7.7.2.1. Regional Setting and Species Descriptions

Five marine turtle species are found in Guyana and the surrounding region. Four marine turtles (green turtle [*Chelonia mydas*], leatherback turtle [*Dermochelys coriacea*], hawksbill turtle [*Eretmochelys imbricata*], and olive ridley turtle [*Lepidochelys olivacea*]) nest on Guyana's beaches. A fifth species, loggerhead turtle (*Caretta caretta*), also occurs offshore Guyana, but rarely comes ashore to nest in Guyana. In addition to relying on sandy beaches for egg-laying, marine turtles rely on healthy coral reef, seagrass, and hard-bottom habitats for food and refuge. Based on available information, post-hatchlings and juvenile green turtles are reported to feed on prey found within sargassum mats (USFWS 2018), while the other marine turtle lifestages are associated with clearer offshore waters or coral reef environments where they prey on a variety of items (Piniak and Eckert 2011).

Green Turtle

Green turtles are generally found in tropical and subtropical waters along coastlines and continental islands between the latitudes of 30° North and 30° South (NOAA 2019). They are distributed worldwide, nesting in more than 80 countries and inhabiting the coastal waters of more than 140 countries (NMFS and USFWS 2007). In the Atlantic Ocean, green turtles are found from Texas to Massachusetts, throughout the Caribbean, and off of the coast of South America. In the Pacific, they are primarily found south of San Diego, California, Hawaii, Guam, and the Mariana Islands. Adult green turtles are benthic herbivores (Bjorndal 1997) and they play an important role in seagrass and macro-algal ecosystems by pruning them, increasing the nutrient cycle, and preventing the creation of sediment (Bjorndal and Jackson 2003; Jackson 2001). After hatching, hatched green turtles swim offshore to find sargassum mats. As they grow larger and older, green turtles move to foraging areas with seagrass beds (Troëng et al. 2005). Green turtles are listed by the IUCN as Endangered (EN) (IUCN 2021).

Leatherback Turtle

Leatherback turtles are the largest of all marine turtle species, but unlike other turtles, they do not have a hard shell. Instead, their carapace is made of small bony plates (osteoderms) covered by leathery skin. Leatherbacks are found in pelagic and coastal tropical and temperate marine waters, where they spend most of the time feeding on jellyfish, salps, and

siphonophores (Dass 2011). Leatherbacks are highly migratory, making distinct and extensive seasonal migrations to foraging and nesting beaches and they show fidelity to both foraging and nesting regions (Fossette et al. 2010). Individuals generally nest from March to mid-July in the northwestern Atlantic (Troëng et al. 2004). Young leatherback turtles remain in tropical latitudes until the length of their shell reaches approximately 100 centimeters (39.4 inches) (Eckert 1999; Eckert 2001). The largest nesting colony in the Caribbean region is in Trinidad (NWA Leatherback Working Group 2018). One of the largest leatherback nesting colonies is located in the estuary of the Maroni River at the border between French Guiana and Suriname (Fossette et al. 2008). Leatherback nests were historically abundant in Suriname and French Guiana, but dramatic population declines have been noted in these areas. The species also nests in Guyana, Venezuela, Colombia, Costa Rica, Puerto Rico, and several islands in the Caribbean. Leatherback turtles are listed by the IUCN as Vulnerable (VU). The species' status is currently under review by IUCN based on recent analysis of nesting trends in the Northwest Atlantic (IUCN 2021; NWA Leatherback Working Group 2019).

Hawksbill Turtle

The hawksbill turtle is a small- to medium-sized marine turtle that has an elongated head that tapers to a point with a beaklike mouth (NOAA 2014). These turtles are circumtropical and can be found in waters from latitudes of 30° North to 30° South in the Atlantic, Pacific, and Indian Oceans. They are found in various wide-ranging locations depending on their lifestage and diet (Mortimer and Donnelly 2008). In the Atlantic Ocean, hawksbill turtles are found within lagoons, ledges, and caves associated with coral reef environments; their diet consists of sponges (NOAA 2014). These types of habitats are generally found northwest of the PDA in the Caribbean Sea. The hawksbill turtle is listed as Critically Endangered (CR) by the IUCN (IUCN 2021).

Loggerhead Turtle

The loggerhead turtle is broadly distributed throughout the world. It is found in the Atlantic, Pacific, and Indian Oceans, as well as the Mediterranean Sea. Loggerhead turtles have oceanic and nearshore life-history phases and sometimes their preferred habitat alternates between offshore and nearshore environments. As juveniles, loggerhead turtles feed on bottom-dwelling marine organisms, but in the open ocean, loggerhead turtles primarily feed near the ocean surface and are particularly associated with sargassum habitat in the North Atlantic Ocean. The loggerhead turtle is classified as EN by the IUCN (IUCN 2021).

Olive Ridley Turtle

The olive ridley turtle is a small turtle compared to the other marine turtles. This species has a circumtropical distribution. Olive ridley turtles are best known for their behavior of synchronized nesting in mass numbers, termed *arribadas*. Similar to other marine turtles, females always return to the same beach to nest where they initially hatched. The olive ridley diet is wide-ranging, consisting of protochordates, jellyfish, tunicates, sea urchins, bryozoans, bivalves, snails, shrimp, crabs, rock lobsters, and sipunculid worms. The Guianas region is known for

supporting important olive ridley colonies (Alvarez-Varas et al. 2016). The olive ridley turtle primarily nests along the French Guiana coast with small nesting areas along the northeastern coast of Venezuela to Suriname and in eastern Brazil (Piniak and Eckert 2011). The olive ridley turtle is classified as VU by the IUCN (Abreu-Grobois and Plotkin 2008).

Marine Turtle Nesting in Guyana

According to available information, the primary marine turtle nesting site in Guyana is Shell Beach, which is located in Region 1 on the northwestern coast of Guyana (e.g., Alvarez-Varas et al. 2016). The exact locations of secondary nesting sites in Guyana change each year with coastal erosion, which either creates or destroys nesting areas, but they are generally distributed along the northwest coast between the Pomeroon River and the Waini River estuaries. Historically, leatherback turtles were the most common species that nested on Guyana's beaches (e.g., Almond Beach); however, many leatherback turtles and eggs were intentionally taken by residents in the late-1980s, so it is difficult to determine whether they remain the most common nesting species (Pritchard 1986). Nonetheless, leatherback and green turtles commonly nest on Guyana's beaches followed by olive ridley and hawksbill turtles, which nest infrequently. According to the Center for Rural Empowerment and the Environment, the primary nesting season for the leatherback, green, hawksbill, and olive ridley turtles in Guyana (Shell Beach) is February to August; nesting occurs at night (PAC 2014).

Habitat Use by Marine Turtles

Because female marine turtles come ashore to nest, the adult (and specifically the female) lifestage is most easily studied and well known; however, much less information is available about habitat use and movements of sub-adults and juveniles. Studies conducted to date have documented the early life history (activities and movements) of marine turtles. Young marine turtles live in the open ocean for the first few years of life, a period that has been termed the surface-pelagic or open-ocean stage. Reich et al. (2007) used stable isotope analysis to confirm that following the initial post-hatching "scramble" to the water, young green turtles lead a carnivorous existence in offshore habitats for 3 to 5 years before making a rapid shift to coastal habitats, where they switch to an herbivorous feeding strategy. At one time, researchers assumed post-hatchling and young juvenile turtles drifted with oceanic currents during their surface-pelagic stage. However, Putman and Mansfield (2015) reported that hatchling green and Kemp's ridley turtles are capable of directional swimming and do exhibit some degree of volitional movement while in the open ocean (McClellan and Read 2007; McClellan et al. 2009; McClellan and Read 2009; McClellan et al 2010).

Threats to Marine Turtle Populations

Similar to other regions, the primary threats to marine turtles in Guyana are poaching, intentional and incidental take during fishing activities, habitat disturbance and degradation, coastal zone development, coastal erosion, lighting, and debris. Population monitoring and conservation activities are limited in Guyana because of logistical challenges associated with the remoteness of primary nesting sites and limited research funding.

Marine turtles are incidentally (e.g., Guimaraes et al. 2017) and sometimes intentionally (e.g., Lagueux et al. 2014) taken in commercial fisheries around the world, which has negatively impacted their populations. Commercial fisheries are one of the biggest threats to the conservation and recovery of marine turtles globally (Wallace et al. 2010). One of the problems is the overlap between commercial fishing grounds and marine turtle foraging areas (Fossette et al. 2014). In some regions around the world (e.g., United States and Costa Rica), turtle excluder devices[25] (TEDs) are required to be installed in trawls, which has been beneficial for marine turtles in many regions. Despite their effectiveness at reducing the bycatch of marine turtles in commercial fisheries, not every country requires TEDs for a variety of reasons (Duarte et al. 2019). Tambiah (1994) estimated that 1,300 marine turtles per year are incidentally taken in trawl nets off Guyana. The mortality rate of taken individuals is around 60 percent. Tambiah (1994) also reported that gillnet fisheries in Guyana and Suriname are an even bigger threat than trawl fisheries, incidentally capturing 21,600 marine turtles per year. The report highlights that the highest bycatch of olive ridley coincides with the peak shrimp fishery (February–March), which is also when the nesting olive ridley turtle arribadas in Suriname take place (January–March).

7.7.2.2. Marine Turtle Data Offshore Guyana

Protected Species Observer Data for Marine Turtles

EEPGL has commissioned the collection of protected species observer data for marine mammals and turtles (also referred to herein as “PSO data”) offshore Guyana since 2015. Data on marine turtles have been collected using visual detection methods during approximately 2,000 hours of survey time, generating the most comprehensive dataset available on marine turtle activity offshore Guyana. A comprehensive summary of PSO data from 2015 through April 2018 was provided as part of the Liza Phase 2 Development Project EIA (RPS 2018). A subsequent summary of PSO observations from May 2018 through April 2019 was provided as part of the Payara Development Project EIA (reference). Six additional PSO surveys have been conducted since that time, only one of which detected marine turtles. This survey occurred between 14 December and 21 May and is included as Appendix N, ExxonMobil Multi AUV Geophysical Survey Protected Species Observer Summary Report.

During the approximately 2,000 hours of survey time in and around the Stabroek Block and between the Stabroek Block and the Guyana coast from May 2015 through April 2019, a total of 17 marine turtles were detected (Figure 7.7-1). The species detected include green, hawksbill, loggerhead, and olive ridley turtles. No leatherback turtles were detected during the surveys. Unidentified shelled marine turtles represented 5 of the 15 observations, followed by five detections of loggerhead turtles, three detections of green turtles, and two detections each of hawksbill and olive ridley turtles.

[25] A TED is a specialized device installed in trawl gear that allows a marine turtle to escape.

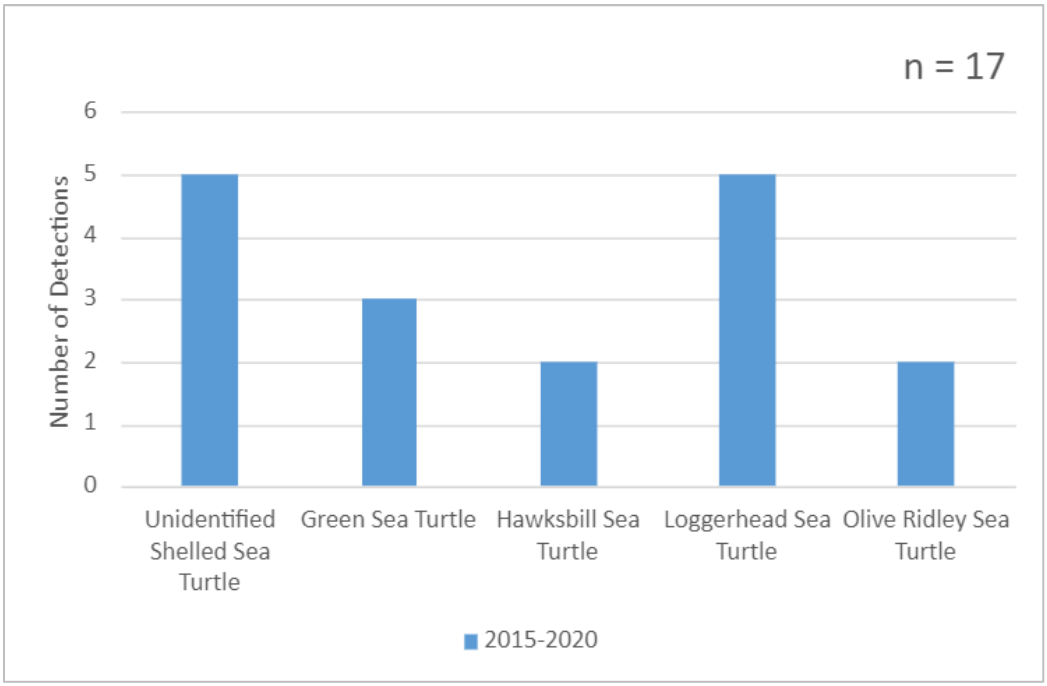


Figure 7.7-1: Number of Visually Detected Marine Turtles during EEPGL-Commissioned Protected Species Surveys 2015–2020

Participatory Fishing Study (January 2019–February 2020)

During the first study year of the EEPGL-commissioned voluntary fish study that occurred from January 2019 to February 2020[26], additional anecdotal information on marine turtles was collected from interviewing fisherfolk. Fisherfolk reported encountering all four species of marine turtles known to nest in Guyana. Leatherback and green turtles were seen or caught and released by study participants in Regions 1, 2, 5, and 6. They indicated that turtles attempted to nest on the sand banks in Riverview (Region 4) and Lima (Region 2) several years ago, but turtles are no longer attempting to nest in those areas given the recently established mangrove planting programs in those regions. Many fisherfolk in Region 2 indicated they have been seeing marine turtles in the seaweed just off the Pomeroon River; it is possible the seaweed could be suitable habitat for green turtles. Almost all of the fisherfolk interviewed in Region 1 reported observing marine turtles during fishing activities and several fisherfolk admitted accidentally catching marine turtles in their fishing gear. A few fisherfolk in Waramuri (Region 1) indicated they frequently encounter marine turtles in the vicinity of Shell Beach. Similarly, fisherfolk from Smith's Creek (Region 1) report encountering many juvenile marine turtles

All of the study participants who acknowledged catching marine turtles indicated that the turtles were released alive. This is due both to the awareness of the important special status of marine turtles and to superstitions held by the fisherfolk. Some fisherfolk believe that catching turtles leads to lower future fish catches, while others believe that the turtles are crying (as a result of

[26] At the time this EIA was prepared, the Participatory Fishing Study was an ongoing study. This EIA presents data from the study that were available at the time the EIA was prepared.

excretion from the turtles' eyes) (Appendix D, Participatory Fishing Study Final Report January 2019–March 2020).

Conservation Group Marine Turtle Satellite Tracking Studies

The Sea Turtle Conservancy actively maps marine turtle movements by placing satellite transmitter tags on individual turtles after nesting. In May 2012, the Sea Turtle Conservancy tracked three leatherback turtles from their nesting site at Shell Beach and discovered that each turtle remained offshore of Shell Beach and in Guyana's territorial waters for several weeks. By the second to third week of June, two had moved farther offshore in transit to the waters off Nova Scotia, while one remained off the coast of Guyana until the third week of July and eventually transited to Honduran waters. One individual swam through the Stabroek Block before moving northward (Sea Turtle Conservancy 2012). These movements are consistent with other researchers (Pritchard 1973; Fossette et al. 2010) that have reported most marine turtles migrate away (approximately a few hundred kilometers) from nesting beaches during post-nesting periods. Most turtles remain relatively close to nesting beaches during the nesting season (Shillinger et al. 2010; Bond and James 2017) because they often return to nesting beaches multiple times to lay additional eggs (multiple clutches). After nesting, marine turtles are highly migratory, making extensive trips to and from foraging areas. Fossette et al. (2010) reported the tracking duration for 16 turtles from 103 to 715 days for recorded distances ranging from 2,834 to 17,614 kilometers (1,761 to 10,945 miles).

EEPGL-Commissioned Tracking Studies

To study turtle movements in Guyana, the Consultants enlisted the assistance of the Chelonian Research Institute in 2018 and 2019 to develop and conduct a research program on marine turtle movements. The program included three deployments to the SBPA, two in 2018 and one in 2019:

- Deployment 1 was undertaken from 21 to 27 March 2018. All field work was permitted through the Guyana Protected Areas Commission and all conditions detailed in the Protected Areas Commission's "Letter of No Objection to ERM Conducting Turtle Telemetry Study in the Shell Beach Protected Area" dated 19 March 2018 were strictly followed. This deployment was the first component of a satellite tagging study conducted to satisfy the conditions of the Environmental Permit for the Liza Phase 1 Development Project. Scientists tagged four green turtles (designated as Sibille, Becky, Violet, and Karin for the purpose of tracking) with satellite tags at Shell Beach during this deployment.
- Deployment 2 was undertaken from 9 to 14 June 2018, for which all field work was conducted in accordance with the permit conditions detailed in the Protected Areas Commission's "No Objection to ERM Conducting 2nd Turtle Telemetry Study in 2018 in the Shell Beach Protected Area" letter dated 31 May 2018. During this deployment, scientists placed satellite tags on three leatherback turtles (designated as Julie, Denise, and Arleen for the purposes of tracking).

- Deployment 3 was undertaken from 7 to 17 May 2019 by the same field team as in 2018 and led by the Chelonian Research Institute. The field work was conducted in accordance with the permit conditions detailed in the Protected Areas Commission's "No Objection to Dr. Kelly Stewart and Team Conducting Turtle Telemetry Research in the Shell Beach Protected Area" letter dated 3 May 2019 and the EPA's "Permission to Conduct Biodiversity Research" letter dated 2 May 2019. During this deployment, scientists placed satellite tags on two green turtles (designated as Sadie and Michelle), and five leatherback turtles (designated as Teij, Kari, Christine, Regina, and Rhoda).

During all deployments, the field teams worked in close collaboration with Protected Areas Commission rangers and local community members during field activities in the SBPA. Representatives from the EPA and University of Guyana were present during the third deployment.

2018 Inter-nesting Movements

Based on tracking data, all individuals showed strong nesting-site fidelity[27] and three different inter-nesting movement behaviors were identified:

- Remaining in the immediate vicinity of Almond Beach, making small near-shore loops;
- Moving moderate distances up and down the Guyana-Venezuela coastline, making small near-shore loops; and
- Moving great distances, making small near-shore loops in the vicinity of Almond Beach and offshore loops between Venezuela, Trinidad, and Guyana.

The 2018 data showed turtles returned to nest between two and six times, exclusively on Almond Beach at about 12-day intervals, except for one green turtle (Violet) who also nested across the Barima-Waini river mouth and at a longer time interval than the other turtles. All turtles demonstrated remarkable nest-site fidelity despite variable displacement distances among nests. With respect to the area used by the turtles during the inter-nesting period, there were no significant differences among species or individuals; however, leatherback turtles were generally found farther from shore than green turtles (Figure 7.7-2).

[27] The tendency of an individual to habitually return to the same area used for a specific lifestage or activity such as nesting or foraging

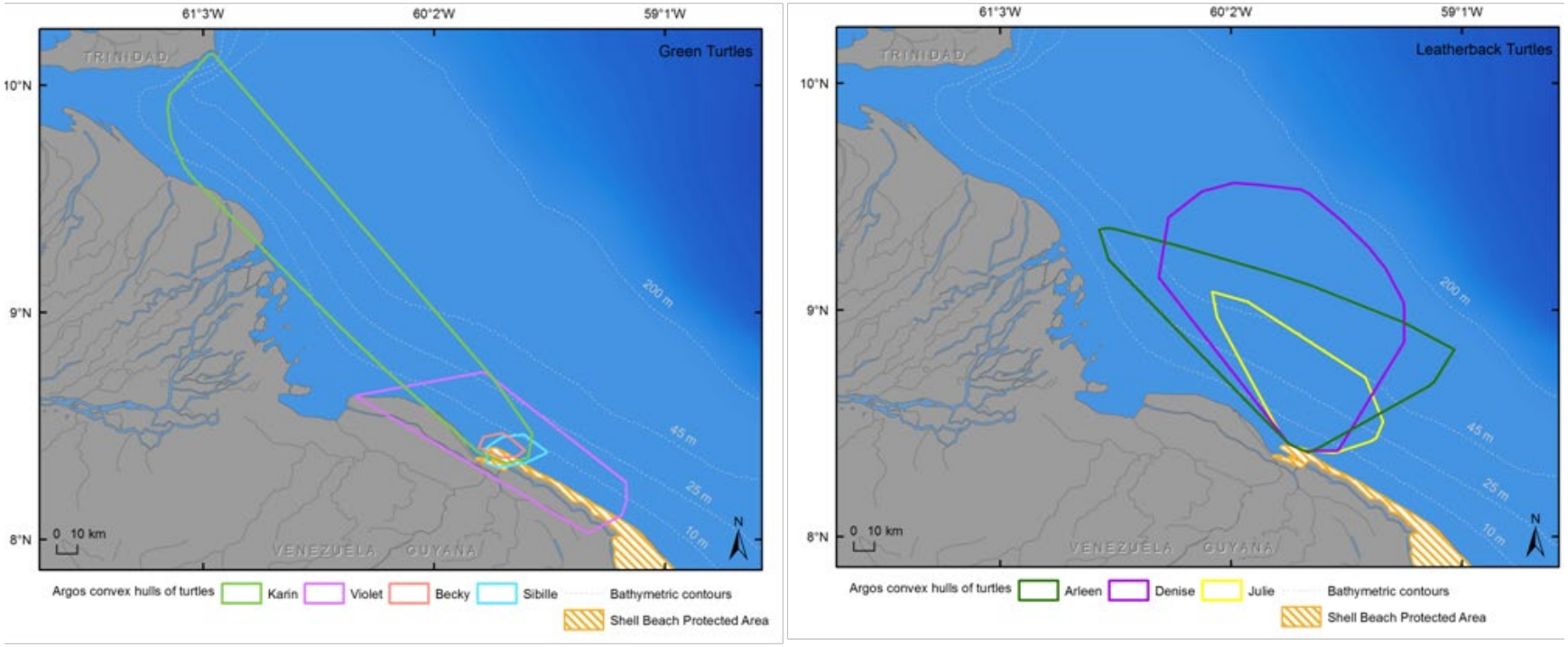


Figure 7.7-2: Spatial Footprints of Green and Leatherback Turtle Inter-nesting Movements from Almond Beach in 2018

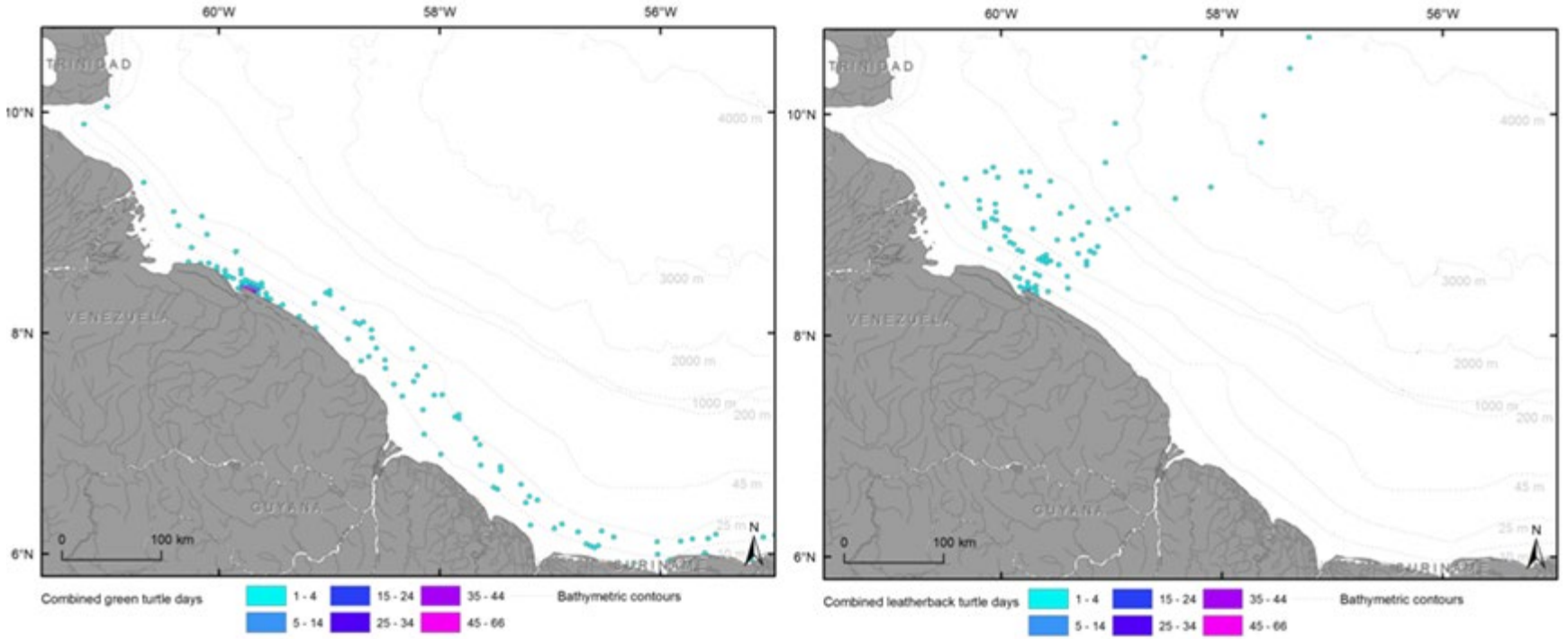
Generally, the turtles' inter-nesting habitat use was concentrated within the territorial seas of Guyana in the direct vicinity of Almond Beach, but it also included the territorial seas of Venezuela and Trinidad. The three leatherback turtles and one of the green turtles demonstrated more itinerant[28] movement behaviors. Karin, a green turtle, moved the farthest during the inter-nesting period, extending 261.7 kilometers (162.6 miles) along the coast, and 50 kilometers (31.1 miles) offshore of the Orinoco River Delta in Venezuela on one loop and reaching the Port of Galeota on the Trinidad coastline on another loop. Julie displayed the most moderate offshore movements (54 kilometers [33.6 miles]) among the leatherback turtles during the nesting season, traveling 104.9 kilometers (65.2 miles) along the coasts of Guyana and Venezuela, and staying around the 50-meter (164-foot) depth contour. Denise, a leatherback turtle, moved the farthest distance from shore (111 kilometers [69.0 miles]), crossing the 100-meter (328.1-foot) depth contour during three inter-nesting loops that spanned 120.4 kilometers (74.1 miles) of shoreline, which included Guyana and Venezuela (see Appendix Q, Final Analysis Report—2018–2020 Shell Beach Turtle Tracking Project). Sibille and Becky remained near their capture locations, spanning 16.7 kilometers (10.4 miles) and 17.8 kilometers (11 miles) of coastline, respectively. These turtles circled the 10-meter (32.8-foot) depth contour, and never traveled more than 11 kilometers (6.8 miles) from shore.

Despite the differences in inter-nesting movements documented above, the center of inter-nesting activity for all tracked turtles was immediately adjacent to the nesting beach.

The two green turtles that exhibited the widest inter-nesting travels (Karin and Violet), dove 16.7 meters (54.8 feet), but spent most of their time within the upper 5 meters (16.4 feet) of the water column. The two comparatively far-ranging turtles traveled into Venezuelan waters, venturing 30 to 40 kilometers (18.6 to 24.9 miles) off the coast near the Orinoco Delta, and traveling approximately 60 kilometers (37.3 miles) southeast of Almond Beach. These two turtles very likely remained near the surface more than the others because the metabolic demands were greater given their extended movement behavior, which forced them to use more energy breathing than the other turtles. These finding suggest that green turtles making long, cross-continental shelf movements before and after the nesting season remain near the surface, which makes spotting them easier for shipboard observers (see Appendix Q, Final Analysis Report—2018–2020 Shell Beach Turtle Tracking Project).

Figure 7.7-3 depicts the movements undertaken by tagged green and leatherback turtles in 2018 during their inter-nesting and early migration periods nearshore and offshore Guyana. The tagged green turtles occurred primarily in the nearshore environments along the Venezuela and Guyana coastlines and the tagged leatherbacks concentrated around the Venezuela coastline, with some individuals venturing further offshore (Figure 7.7-3).

[28] Moving from place to place



A synopsis of habitat use of turtles nearshore and offshore Guyana presented as the number of days that turtles occupied individual hexagons of approximately 16.25 square kilometers (4,015.5 acres). This encompassed the turtles' inter-nesting periods and part of their migration period.

Figure 7.7-3: Synopsis of Habitat Use of Turtles Nearshore and Offshore Guyana in 2018

Leatherback turtles occupied deeper water than green turtles during the inter-nesting period. Green turtles spent most of their time in less than 5 meters (16.4 feet), while leatherback turtles spent most of their time in less than 10 meters (32.8 feet) of water. Leatherback turtles are known to dive deep. The one leatherback turtle with a depth sensor tag, Denise, dove to 134.5 meters (441.3 feet) during the inter-nesting period. Most of the time, Denise made dives within the upper 10 meters (32.8 feet). A week after she migrated away from the nesting site, she started making deep dives every two or three days, the deepest of which (560.5 meters [1,839 feet]) was the day before her last transmission, where she was in water depths exceeding 5,000 meters (3.1 miles). Details on the vertical habitat use of turtles during their entire respective tracking periods are summarized in Table 7.7-2 (see Appendix Q, Final Analysis Report—2018–2020 Shell Beach Turtle Tracking Project).

Table 7.7-2: 2018 Turtle Daily Vertical Habitat Use

Turtle ID	Water Depth (m)		Turtle Depth (m) [a]		Maximum Dive Depth (m) [b]	
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Green Turtles						
173290 Sibille	10.5 (9.1)	1.0–42.0	-	-	-	-
173293 Violet	9.9 (6.9)	1.0–42.0	6.9 (5.4)	0.0–34.0	12.5 (6.1)	1.8–33.8
173291 Becky	12.2 (11.1)	1.0–69.0	-	-	-	-
173294 Karin	9.1 (9.1)	1.0–48.0	6.0 (5.1)	0.5–37.0	10.3 (6.8)	2.8–37.0
Leatherback Turtles						
173284 Julie	58.9 (198.4)	1.0–1,065.0	-	-	-	-
173288 Denise	1,400.9 (1961.8)	1.0–5,437.0	22.7 (33.5)	0.5–560.5	108.3 (100.0)	7.3–560.5
173285 Arleen	3,909.9 (1932.3)	1.0–5,963.0	-	-	-	-

m = meters; SD = standard deviation

[a] Turtle daily vertical habitat use (i.e., depth) was inferred from sampling bathymetric maps and from dive data collected by the turtle tags. Sibille, Becky, Julie, and Arleen were not equipped with dive recorders.

[b] This table shows the mean and standard deviation as well as the range. For example, the maximum depth of a given dive was on average 10 to 13 meters (32.8 to 42.7 feet) for green turtles. Maximum dives of 30 to 40 meters (98.4 to 131.2 feet) were rare but are captured in the range column of the table. The same logic applies to leatherbacks.

2018 Post-Nesting Dispersal Movements

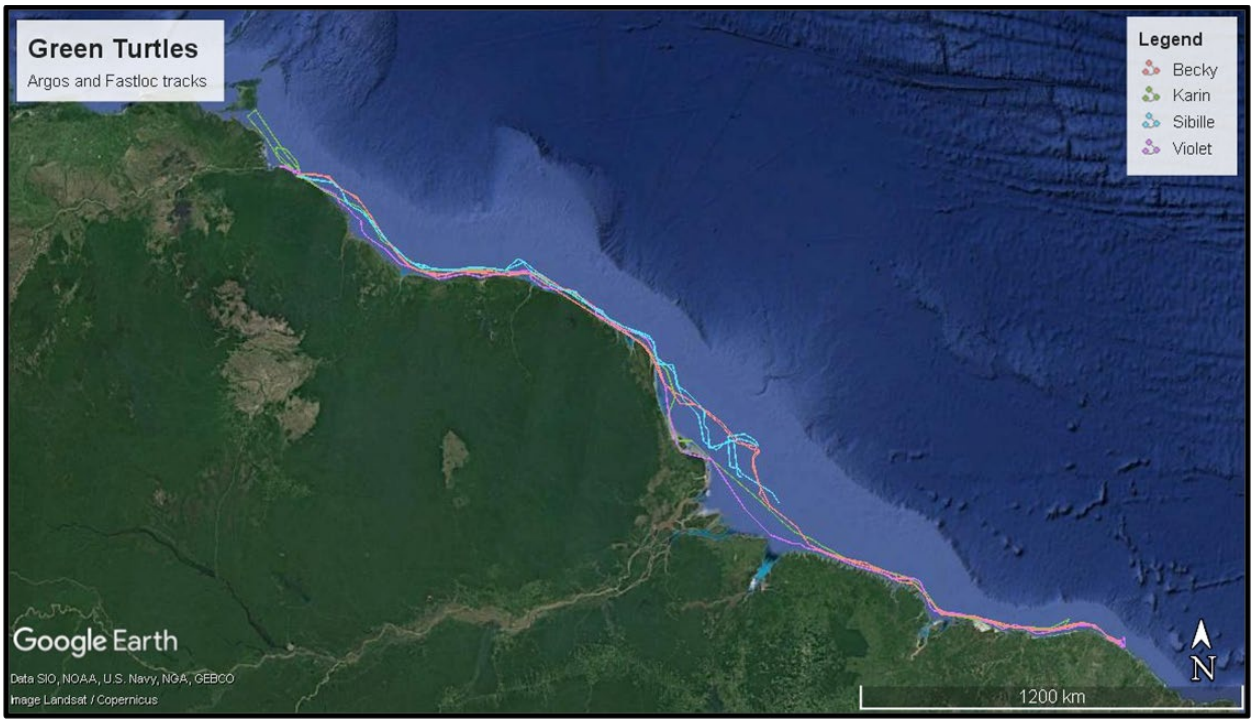
Researchers were able to track the movement pattern and behavior after departing the Shell Beach nesting site to their foraging grounds for all of the tagged turtles. All four green turtles migrated southeast to Brazil, following a near-shore corridor across an average distance of 2,485 kilometers (1,544.1 miles); all three leatherback turtles initially headed directly out to sea in a northeasterly direction. Both green and leatherback turtles used much deeper waters during their migration periods than during other periods. Both green turtles made various deep dives

(60 meters [196.9 feet]) before or after moving near major river mouths (i.e., the Essequibo River, Guyana; the Corentyne River, Suriname; the Amazon and Pará rivers, the Mearima River / Arraial Bay, and the Parnaíba River, Brazil). Three green turtles displayed movements to the foraging grounds near Ceará, Brazil. Two of three turtles overlapped geographically in the area, adjacent to the Mundaú River Estuary Environmental Protection Area. The three green turtles displayed similar foraging habitat use (area) and movements (dispersal from foraging centroid) among individuals, and their locations were at similar distances from shore as during the inter-nesting period, although water depths in the foraging area were slightly deeper.

The fourth green turtle and the leatherbacks were not tracked to their foraging grounds prior to the satellite tags ceasing to transmit. The first leatherback migrated 4,634 kilometers (2,879.4 miles) over 96 days. Based on her route, it appeared she was heading for the Laurentian Channel, which corresponds to previous research. Canadian waters off Nova Scotia, Cape Breton, and Newfoundland have been previously described as critical foraging habitat for leatherback turtles.

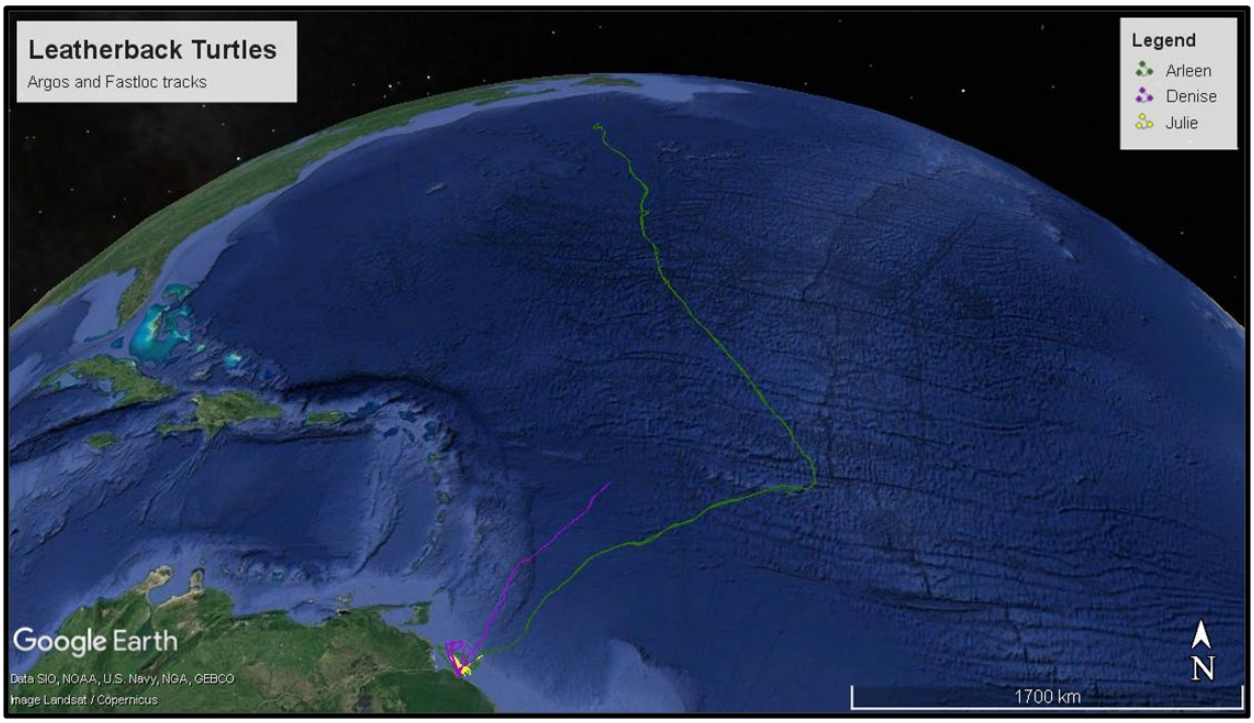
To examine the influence of ocean currents on the turtle movement, movement tracks were overlaid on monthly-averaged geostrophic current (altimetry) imagery, which included sea surface height (SSH) and velocity. Examining green turtle migrations showed the turtles occupying a narrow band close to the shore, where the current velocity and SSHs were the lowest; SSHs were, however, elevated near the major river mouths in Brazil. Leatherback turtles began to migrate in early to mid-July, which coincided with the onshore movement of the Guiana Current near Shell Beach; this formed a large divergent zone approximately 200 kilometers (124.3 miles) offshore.

In summary, green turtles followed a narrow migration corridor along the coastline after nesting in 2018, avoiding the opposing Guiana and North Brazil western boundary currents. In contrast, leatherback turtles dispersed into the high seas after nesting, taking an initial northeasterly course. Figures 7.7-4 and 7.7-5 show the recorded track paths for green and leatherback turtles.



Where double lines appear for a given turtle, this indicates deviations between the tracks derived from Argos and Fastloc location data. In most cases the difference is unapparent.

Figure 7.7-4: 2018 Migration Routes of Green Turtles Tracked from Shell Beach



Where double lines appear for a given turtle, this indicates deviations between the tracks derived from Argos and Fastloc location data. In most cases the difference is unapparent.

Figure 7.7-5: 2018 Migration Routes of Leatherback Turtles Tracked from Shell Beach

2019 Inter-nesting Movements

All individuals tagged in 2019 showed strong nesting-site fidelity to their capture locations throughout the inter-nesting period. Three inter-nesting movement behaviors were identified:

- Immediately departing from the nesting region;
- Remaining in the immediate vicinity of Almond Beach and making small near-shore loops; and
- Moving large distances and making offshore loops between Venezuela, Trinidad and Tobago, and Guyana.

The 2019 data showed the turtles returned to their nests between zero and four times exclusively on Almond Beach at approximately 12-day intervals. Green turtles demonstrated similar re-nesting intervals to leatherback turtles during the 2019 season. All turtles demonstrated remarkable nesting-site fidelity irrespective of their maximum displacements from Almond Beach. With respect to the area used by the turtles during the inter-nesting period, there were no significant differences among species or individuals; however, leatherback turtles were generally found farther from shore than green turtles (Figure 7.7-6)

Generally, the inter-nesting habitat use of the turtles was split between the territorial seas of Guyana and Venezuela, and the territorial seas of Trinidad and Tobago. Of the green turtles, Michelle left the nesting region immediately after nesting, whereas Sadie remained near her capture location, spanning 56.8 kilometers (35.3 miles) of the Guyana coastline and never more than 16 kilometers (9.9 miles) from shore. The five leatherback turtles demonstrated the most itinerant movement behaviors. Teij's inter-nesting movements were the most extensive, spreading 560 kilometers (348 miles) between Guyana and Tobago over 24 days, and she missed her second-to-last expected nesting interval during this time. Rhoda's inter-nesting movements were the nearest to shore among the leatherback turtles, remaining within 51 kilometers (31.7 miles) of the coast.

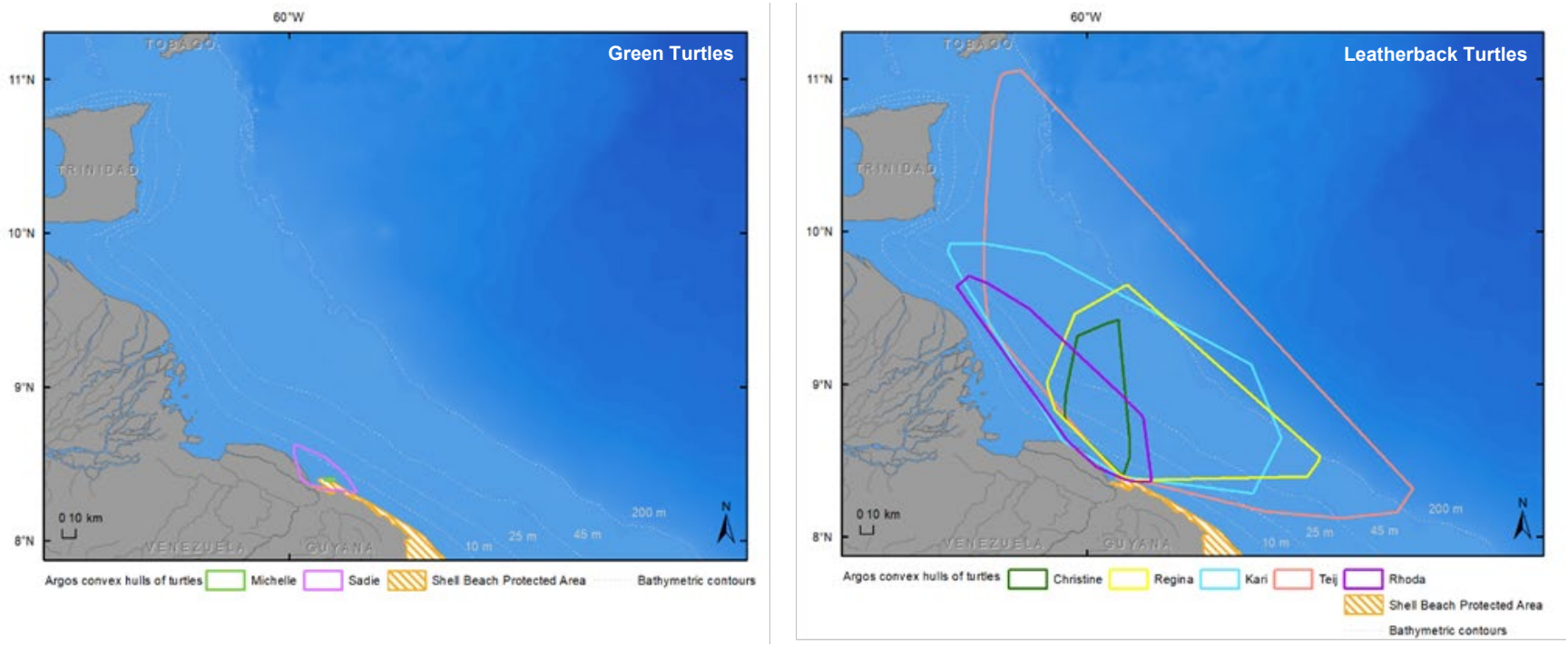


Figure 7.7-6: Spatial Footprints of Green and Leatherback Turtle Inter-nesting Movements from Almond Beach in 2019

Kari made the deepest dive at a maximum depth of 1,413.5 meters (4,637.5 feet), compared to the dive depth of Christine, Regina, and Rhoda ranging between 515 and 680 meters (1,689.6 and 2,231 feet) (Table 7.7-3).

Table 7.7-3: 2019 Turtle Daily Vertical Habitat Use

Turtle ID	Water Depth (m)		Turtle Depth (m) [a]		Maximum Dive Depth (m) [b]	
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Green Turtles						
173292 Michelle	8.7 (7.5)	2.0–43.0	—	—	—	—
173295 Sadie	14.9 (12.4)	2.0–75.0	11.4 (7.5)	0.5–43.0	18.0 (8.9)	2.8–42.0
Leatherback Turtles						
173286 Teij	3,823.2 (2,131.9)	2.0–6,286	—	—	—	—
173287 Kari	3,535.7 (2,236.8)	2.0–5,814.0	33.3 (59.8)	0.5–1,413.5	161.1 (146.1)	3.8–1,413.5
173289 Christine	2,349.2 (2,486.0)	2.0–7,093.0	32.5 (46.7)	0.5–516.0	179.0 (135.8)	4.8–515.8
180748 Regina	2,445.0 (2,512.0)	2.0–6,455.0	44.1 (53.0)	0.5–680.0	151.4 (111.9)	7.8–680.0
180749 Rhoda	800.9 (1,758.4)	1.0–5,971.0	15.4 (30.9)	0.5–590.5	75.8 (84.3)	4.3–590.3

m = meters; SD = standard deviation
[a] Turtle daily vertical habitat use (i.e., depth) was inferred from sampling bathymetric maps and from dive data collected by the turtle tags. Michelle and Teij were not equipped with dive recorders.

2019 Post-nesting Dispersal Movements

All of the tagged turtles were tracked from their nesting sites on Almond Beach to or near their foraging grounds. Both green and leatherback turtles used deeper waters during their migration period than in prior tracking periods. Similar to 2018, the two green turtles in the study (Michelle and Sadie) headed southeast to Brazil by following a near-shore corridor across an average distance of 2,696.5 kilometers (1,675.5 miles) (Figure 7.7-7). Michelle stopped at a well-known green turtle foraging area (Naro-Maciel et al. 2007; Godley et al. 2003) near Almofala, where she foraged for 24 days before moving farther down the coast and settling at another site in the state of Rio Grande do Norte, where she remained for 68 days prior to her transmission ceasing. Sadie foraged farther north near Parnaiba, Brazil, until her final transmission 62 days later. Both green turtles used slightly deeper water depths than during the inter-nesting period and displayed similar habitat use and movements between sites at a similar distance from shore as their inter-nesting periods.

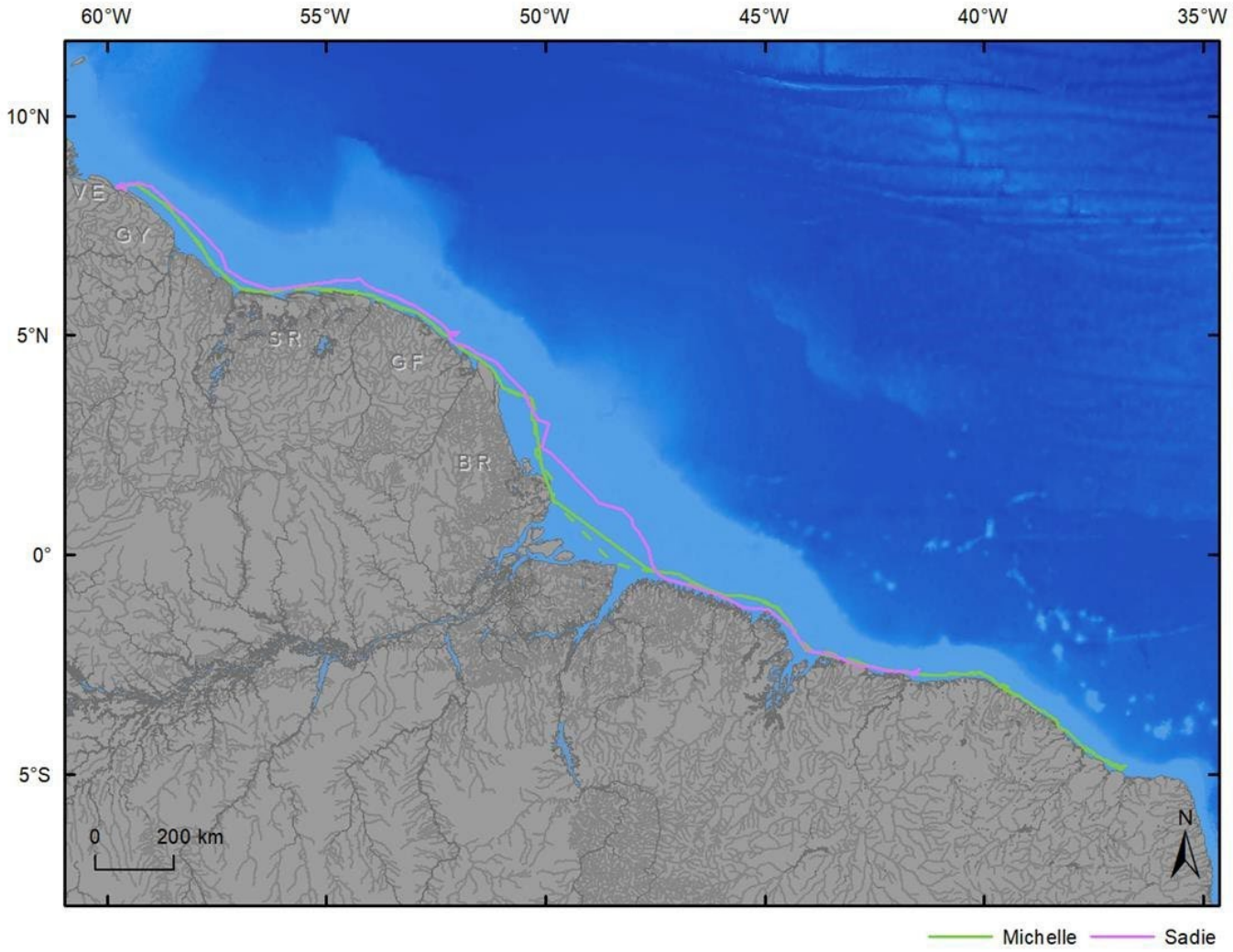


Figure 7.7-7: 2019 Migration Routes of Green Turtles Tracked from Shell Beach

For the first time, both coastal and oceanic foraging habitats for the leatherbacks were observed. The indicators for these periods were area-restricted search movements, coupled with a change in dive behavior marked by a progression of shallow dives, which were consistent in both types of habitats. Two of the leatherback turtles (Christine and Rhoda) initially headed directly out to sea in a northeasterly direction towards the coastal southeastern United States (Figure 7.7-8). These turtles remained in near-shore waters, moving up and down the coast of the United States—likely in search of jellyfish. The coastal zone of the southeastern United States has been identified as important foraging habitat for leatherbacks (Eckert et al. 2006; Fossette et al. 2014; Stewart et al. 2016).

The other three leatherbacks (Teij, Kari, and Regina) headed due north to the offshore Canadian Maritime Provinces (Figure 7.7-8). Canadian waters off Nova Scotia, Cape Breton, and Newfoundland have also been previously described as critical foraging habitat for leatherback turtles (James et al. 2005, 2006) and capture studies in this area have previously confirmed flipper tag recoveries from the Guianas (James et al. 2007). These three turtles displayed foraging behavior in this region near Placentia Bay, Newfoundland, and over abyssal depths (more than 3,000 meters [9,842.5 feet]) off of Nova Scotia. In some cases, they remained in these areas for prolonged periods, but in others they moved to other sites quickly, likely depending upon the availability of prey resources encountered. The leatherback turtles concentrated their foraging dives in the upper 30 meters (98.4 feet) of the water column.

The leatherbacks tended to dive deeper than the green turtles during their migration; however, similar to 2018, they remained in the upper 500 meters (1,640.4 feet) of the water column. Kari had the deepest recorded dive from the study, reaching a depth of 1,413.5 meters (4,637.5 feet). Leatherbacks have been previously known to dive deeper than 1,000 meters (3,280.8 feet). These dive depths are rare and the reasons unknown; however, three possibilities have been proposed: thermoregulation, predator avoidance, and scouting prey. Of these possibilities, the “prey scouting” theory has emerged as the most credible and assumes the turtles use these dives to locate concentrations of prey items and then return to the surface to wait for them to rise through the water column at night to consume at their leisure near the surface (Houghton et al. 2008). The leatherback turtles in the study recorded deeper water depths during foraging than during the inter-nesting period, and the turtles foraging in Canadian waters occupied deeper waters than the turtles that remained in the southeastern United States. The habitat use areas and distances from shore were similar between inter-nesting and foraging periods, but dispersal among sites was greater than during the inter-nesting period.

The information presented in this section was collected from relevant scientific literature and the largest collection of telemetry data for marine turtles in Guyana’s territorial waters to date. These data have confirmed previous scientific consensus on the behavior of adult marine turtles during the internesting and post-nesting periods. They have also conclusively demonstrated, through repeated observations, defined behavioral patterns for the most common marine turtle species offshore Guyana. For these reasons, the Consultants consider the information presented in this section adequate to support an assessment of likely Project impacts on marine turtles.

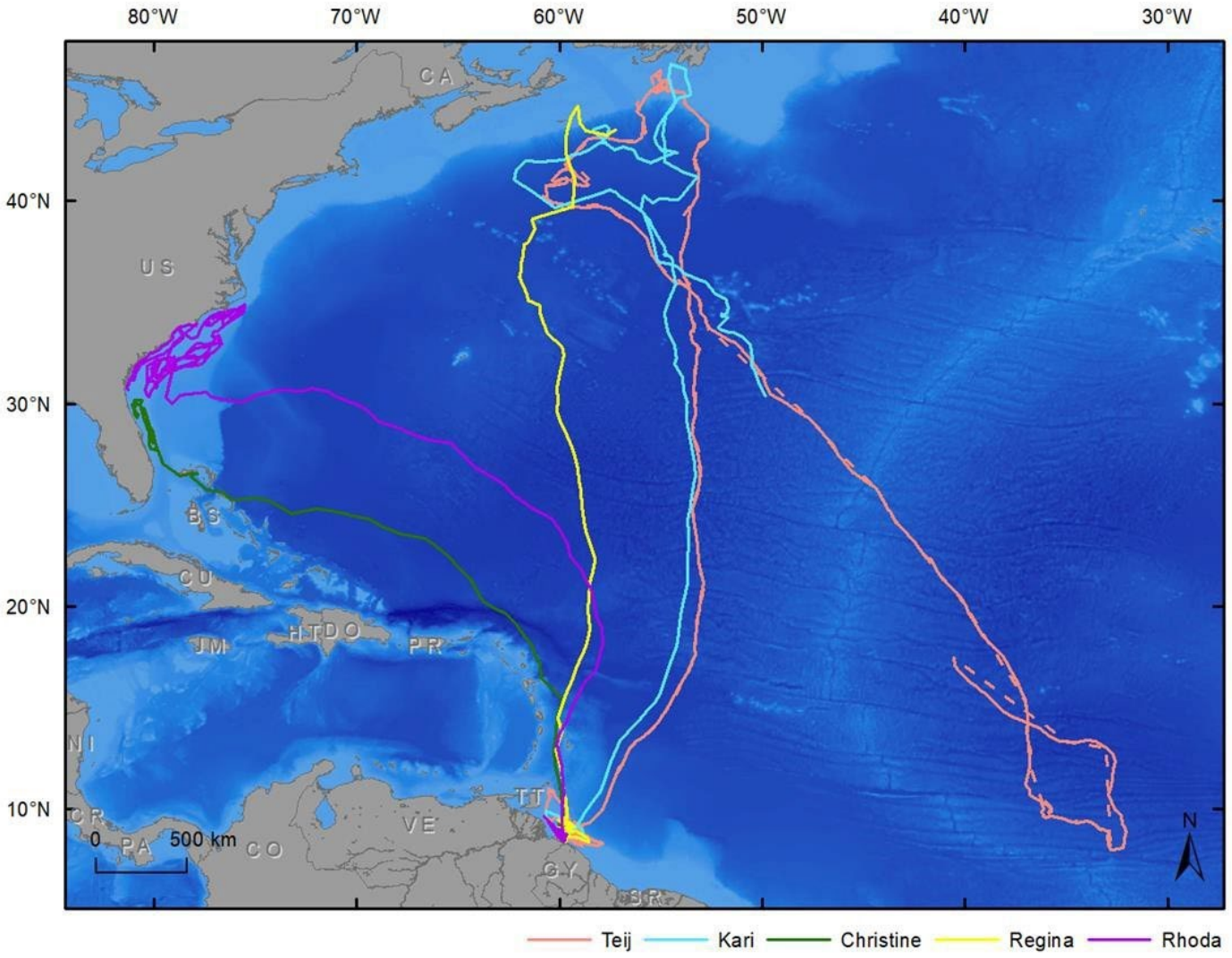


Figure 7.7-8: 2019 Migration Routes of Leatherback Turtles Tracked from Shell Beach

7.7.3. Impact Assessment—Marine Turtles

As described above, leatherback, green, hawksbill, loggerhead, and olive ridley turtles are found in Guyanese waters and could be encountered in the PDA. Four of these species—green turtle, leatherback, hawksbill, and olive ridley turtle—nest on Guyana's beaches, particularly in the SBPA, located near Guyana's border with Venezuela. Loggerhead turtles occur in offshore Guyanese waters, but rarely come ashore to nest.

7.7.3.1. Relevant Project Activities and Potential Impacts

As shown in Table 7.7-4, planned Project activities could potentially impact marine turtles through auditory injury (i.e., as a result of exposure to sound from Project activities), disturbance leading to changes in behavior (e.g., from underwater sound, lighting, and/or actions from Project activities), or toxicological effects (e.g., as a result of exposures to Project vessel discharges).

Potential impacts on marine turtles from unplanned events are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

Table 7.7-4: Summary of Relevant Project Activities and Key Potential Impacts—Marine Turtles

Stage	Project Activity	Key Potential Impact
Development Well Drilling SURF/FPSO Installation, Commissioning, and Start-up	Vessel operations	• Displacement from habitat to avoid disturbance from vessel activity • Sound exposure leading to PTS injury
	Power generation	• Displacement from habitat to avoid disturbance from vessel activity or sound • Sound exposure leading to PTS injury
	VSP and pile driving	
	Remotely operated vehicle operations	
	Lighting on drill ship and installation vessels	• Disturbance to at-sea hatchlings and adults
	Permitted drill cuttings and fluids discharge	• Exposures to permitted discharges, potentially leading to toxicological impacts on sensitive lifestages (at-sea hatchlings)
	Permitted liquid waste discharge	
Production Operations	Vessel operations (e.g., FPSO supply barges, support vessels, drill ship, platform supply vessels, fast supply vessels, large crane vessel, fast supply vessel, field intervention vessel, light installation vessel, and multi-purpose support vessels)	• Displacement from habitat to avoid disturbance from vessel activity or sound
	Power generation	
	Operation of tankers, tugs, and supply and support vessels	
	Well stream production, processing, and storage operations	
	Permitted cooling water and produced water discharge	

Stage	Project Activity	Key Potential Impact
	Other permitted effluent discharges to the sea	• Exposures to permitted discharges, potentially leading to toxicological impacts on sensitive lifestages (at-sea hatchlings)
	Lighting on FPSO	• Disturbance to at-sea hatchlings and adults
Decommissioning	Vessel operations	• Displacement from habitat to avoid disturbance from vessel activity • Exposures to permitted discharges, potentially leading to toxicological impacts on sensitive lifestages (at-sea hatchlings)

7.7.3.2. Magnitude and Sensitivity Definitions for Potential Impacts on Marine Turtles

Following the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude ratings of potential impacts on marine turtles are determined based on geographic extent, frequency, duration, and intensity.

The intensity of potential impacts on marine turtles is defined according to the definitions provided in Table 7.7-5.

Table 7.7-5: Definitions for Intensity Ratings for Potential Impacts on Marine Turtles

Criterion	Definition
Intensity	Negligible: No Project-related change in marine turtle behavior or injury, or disturbance across only a very limited area.
	Low: Limited Project-related disturbance or injury of marine turtles is perceptible, potentially causing slight changes in the behavior of marine turtles.
	Medium: Project-related disturbance or injury of marine turtles is evident, potentially leading to limited mortality or impacts on life functions (e.g., feeding, breeding, migration route changes).
	High: Project-related disturbance or injury of marine turtles is sufficient to cause extensive mortality or chronic behavioral changes at a population level.

As discussed in Section 7.1.3, Impact Assessment—Protected Areas and Special Status Species, because the marine turtles occurring in the Project AOI are listed as CR (one species), EN (two species), or VU (two species) by IUCN, the marine turtles impact assessment applied the sensitivity ratings for special status species, as defined in Table 7.7-6. Applying a conservative approach and using the highest applicable sensitivity rating, this yields a **High** sensitivity. As discussed below, this sensitivity rating applies to all impacts other than anthropogenic disturbance at sea.

Contrary to other potential impacts, anthropogenic disturbance of turtles at sea is not known to be a major contributor to declines in listed turtle species. Accordingly, the sensitivity rating for this particular impact was not defined based on marine turtles' listing status, but rather on the basis of their expected propensity to adapt to occasional disturbance. In addition, turtles are

expected to be less sensitive to impacts when at sea compared to when nesting or immediately leading up to or following nesting. This is due to the vast areas in which turtles disperse during the non-nesting period and the very low abundance of turtles in the offshore environment in and near the PDA (based on approximately 2,000 hours of survey data collected in the Stabroek Block and between the Stabroek Block and the Guyana coast from 2015 through 2020). On this basis, resource sensitivity for marine turtles is considered **Low** for impacts related to anthropogenic disturbance (including disturbance from artificial lighting).

Table 7.7-6: Definitions for Resource Sensitivity for Potential Impacts on Marine Turtles (Adopted from Potential Impacts on Special Status Species)

Criterion	Definition
Sensitivity	Negligible: Species with no scientifically recognized (e.g., IUCN Red List or regional equivalent) elevated conservation status or other specific value or importance attached to them.
	Low: Species and sub-species of Least Concern on the IUCN Red List (or not meeting criteria for medium or high value), or without specific anatomical, behavioral, or ecological susceptibilities to potential Project-related impacts.
	Medium: Species listed as VU or Near Threatened on the IUCN Red List; species protected under national legislation; nationally restricted range species; nationally important numbers of migratory or congregatory species; and species not meeting criteria for high value.
	High: Species on IUCN Red List as CR or EN; species having a restricted range (i.e., endemic species to a site, or found globally at fewer than 10 sites, fauna having a distribution range less than 50,000 square kilometers/19,305 square miles), internationally important numbers of migratory or congregatory species, key evolutionary species, and species vital to the survival of high value species.

7.7.3.3. Characterization of Impacts—Auditory Injury from Anthropogenic Underwater Sound

The main sources of underwater sound associated with development well drilling and installation, activities are from VSP[29] activities (generating impulsive sound) and marine vessels (generating non-impulsive sound). The primary sources of sound from FPSO and SURF installation activities are from impact pile drivers for the FPSO mooring system and selected SURF equipment, such as manifolds (generating impulsive sound), and marine vessels (generating non-impulsive sound). Sound sources from production operations and decommissioning activities are primarily limited to marine vessels (generating non-impulsive sound).

Underwater sound can potentially cause a variety of impacts on marine turtles, such as behavioral changes in life functions (e.g., feeding, breeding, migration route deviations) or direct physical impacts affecting auditory systems.

[29] The VSP has a small source that produces seismic impulses over a period of time (for the purposes of this assessment, it was assumed that the source will produce 20 to 40 seismic pulses, less than 1 second in length, over a 6- to 12-hour period). The wavefield generated by this source is recorded by instruments in the borehole.

Marine Turtle Auditory Functions

Marine turtles are capable of hearing sound despite lacking a visible external ear, but the biological significance of hearing in turtles is unknown. Marine turtles are not known to use sound to communicate like cetaceans, but they do use it for navigation, locating prey, avoiding predators, and general environmental awareness (Piniak et al. 2012). Hearing capabilities have been studied in only a few individual marine turtles, but the available data suggest that turtles have limited hearing capacity compared to other marine taxa (e.g., cetaceans).

All species of marine turtles can detect low-frequency sound, with indications that they have the highest hearing sensitivity in the frequency range of 100 to 700 hertz (Hz) (Bartol and Musick 2003; Piniak et al. 2012; Nelms et al. 2016). The auditory capabilities of marine turtles appear to vary among species. According to Piniak et al. (2012), green turtles detected tonal stimuli between 50 and 1,600 Hz underwater (maximum sensitivity: 200–400 Hz) and 50 and 800 Hz in air (maximum sensitivity: 300–400 Hz), leatherbacks detected tonal stimuli between 50 and 1,200 Hz underwater (maximum sensitivity: 100–400 Hz) and 50 and 1,600 Hz in air (maximum sensitivity: 50–400 Hz), and hawksbills detected tonal stimuli between 50 and 1,600 Hz in both media (maximum sensitivity: 200–400 Hz). The same study reported that marine turtles were more sensitive to airborne stimuli than underwater stimuli in terms of sound pressure, but they were more sensitive to underwater stimuli in terms of sound intensity. These hearing ranges overlap the sound produced by seismic airguns (Nelms et al. 2016).

Since marine turtles have been shown to hear and respond to low-frequency sounds, modeling results pertinent to LFCs (see Section 7.5.3, Impact Assessment—Marine Mammals) were used as a proxy for potential acoustic injury predictions for marine turtles. As described in Section 7.5.3, modeling predicted that impulsive underwater sound from VSP will attenuate to PTS onset acoustic thresholds for LFCs at maximum horizontal distances of 73 meters (approximately 240 feet), based on the more conservative injury criteria for the LFC marine mammal hearing group.

Observational records and dive profile data for turtles tagged during the EEPGL-commissioned turtle tagging program suggest that most marine turtles occupy the upper 50 meters (164.0 feet) of the ocean during the inter-nesting period (see Appendix Q, Final Analysis Report—2018–2020 Shell Beach Turtle Tracking Project), although leatherback turtles are known to dive deeper during their migration journeys. The VSP source for the Project will be located within 5 meters (approximately 16 feet) of the ocean surface, so marine turtles may be present at the same general depth as this source. Modeling indicates that marine turtles will be susceptible to PTS if they approach closer than 73 meters (239.5 feet) from an active seismic source and could encounter sufficient sound levels to disturb them, which could cause them to either avoid the sound source or could attract them to the sound source. Preliminary studies indicate that individual turtles are equally likely to move toward a sound source than from it. While the horizontal extent of the modeled potential auditory injury impact zone is significantly larger for pile driving than for VSP, the shallowest piles necessary for the Project's spread mooring system would be installed at a depth of approximately 1,690 meters (5,445 feet) below the sea surface. Marine turtles are not known to dive to this depth. Leatherback turtles have been

reported to dive 1,186 meters (3,891.1 feet; López-Mendilaharsu et al. 2008) and in 2019, one of the EEPGL-tagged leatherbacks dove to 430.8 meters (1,413.5 feet), but there is no scientific evidence of turtles diving to a sufficient depth to be exposed to harmful sound levels from pile driving.

The only other low-frequency sound that marine turtles could potentially be exposed to as a result of the Project, other than VSP, would derive from vessels operating in the PDA, and modeling indicates vessel sounds will decrease below the threshold for acoustic injury to LFCs at 5 to 6 meters (approximately 16 to 20 feet) from the source (see Appendix H, Underwater Sound Modeling Report).

Magnitude of Impacts—Potential Auditory Injury from Anthropogenic Underwater Sound

Potential auditory injury-related impacts on marine turtles from Project-related underwater sound will be limited to the PDA (where pile driving and VSP will occur), so the geographic extent is considered to be the **Direct AOI**. The potential for acoustic injury impacts on marine turtles is limited primarily to impulsive sound during the drilling and installation stages (pile driving and VSP activities), which will be **Episodic** in nature and **Medium-term** (as they will occur in aggregate more than a week but less than a year). Potential impacts from non-impulsive sound will occur during all Project stage, so the impact would be **Continuous** and either **Long-term** (in the case of drilling and installation) or **Medium-term** (in the case of decommissioning).

The following considerations formed the basis for the assignment of an intensity rating:

- The activity that presents the greatest risk of acoustic injury (from a sound level perspective) to marine turtles (pile driving) will only occur during the initial installation stage, and therefore represents a relatively short-term source of potential impact (greater than 1 week but less than 1 year). The potential for marine turtles to be exposed to sufficient sound levels at a sufficient duration to cause auditory injury is extremely small, or possibly non-existent, due to the depths at which sound above the injury threshold will occur. Most of the marine turtles expected to be present in the PDA do not dive to the depths that would be required to reach these threshold levels or, if they do (such as occasional deep diving by leatherback turtles), they do not remain submerged at these depths for sufficient time to experience acoustic injuries.
- EEPGL has committed to using MMOs and soft-start procedures for VSPs in accordance with JNCC (2017) guidelines and soft starts for pile driving to further reduce the potential for impacts on marine mammals, which would be expected to reduce the potential for impacts on marine turtles.

The intensity of potential acoustic injury impacts is considered **Negligible** for the drilling and installation stage of the Project when a marine turtle could be exposed to sound from pile driving and VSP. Based on the very small distance to which auditory injury threshold levels are expected to propagate from the FPSO and marine vessels, the intensity of potential acoustic injury impacts is also considered **Negligible** for the production operations and decommissioning

stages, when the underwater sound present in the Direct AOI will be limited to power generation and vessel traffic.

These ratings yield a magnitude rating of **Negligible** for potential auditory impacts on marine turtles (Table 7.7-7).

Table 7.7-7: Magnitude Ratings for Auditory Injury from Anthropogenic Underwater Sound

Stage	Resource—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Drilling and Installation (impulsive sound activities)	Marine turtles – auditory injury from sound exposure	Direct AOI	Negligible	Episodic	Medium-term	Negligible
Drilling and Installation Production Operations (non-impulsive sound activities)	Marine turtles – auditory injury from sound exposure)	Direct AOI	Negligible	Continuous	Long-term	Negligible
Decommissioning (non-impulsive sound activities)	Marine turtles – auditory injury from sound exposure	Direct AOI	Negligible	Continuous	Medium-term	Negligible

Impact Significance—Potential Acoustic Injury from Anthropogenic Underwater Sound

Based on the magnitude of impact and resource sensitivity ratings described above, the pre-mitigation significance rating for potential acoustic injury impacts on marine turtles is **Negligible**.

7.7.3.4. Characterization of Impacts—Disturbance from Underwater Sound

Anthropogenic sounds below injury thresholds have the potential to mask relevant sounds in the animals' environment (Hildebrand 2005); however, there are no quantitative data demonstrating masking impacts for marine turtles, and it is currently understood that turtles do not use sound to communicate (Piniak et al. 2012). As such, the potential risk of impacts from masking is considered negligible.

Aside from fishing and entanglement, which are the greatest and most well documented sources of marine turtle disturbance, injury, and mortality, limited information exists describing the potential impacts associated with anthropogenic disturbance of turtles at sea and whether and to what extent these disturbances contribute to population declines in marine turtle populations. Behavioral responses to sound by marine turtles can vary from swimming to the surface and remaining at the surface to increasing their swimming speed and displaying erratic behavior (Nelms et al. 2016). Startle responses to sudden sounds have been observed in marine turtles. For example, McCauley et al. (2000a, 2000b) found that turtles showed

behavioral responses to approaching seismic survey sound at approximately 166 decibels (dB) re 1 microPascal (µPa)[30], and more significant disturbance at 175 dB re 1 µPa. Startle responses and other behavioral changes are more likely from high-level impulsive sound sources, such as VSP activities, rather than from non-impulsive sound sources such as vessels. Avoidance of the noise source is another common behavior.

One study found that post-nesting loggerhead turtles use the same post-nesting habitat areas year after year even though they contain vessel traffic and other disturbing activities, despite having closer choices of protected habitats with little or no vessel traffic or disturbing activities. This suggests that the drive for post-nesting dispersal habitat site fidelity is stronger than the turtle's desire or ability to avoid areas with high levels of human or vessel activity, or that they simply do not consider or respond to human activity as a threat (Zbinden et al. 2008). Nevertheless, increased activity in the PDA and between the PDA and shorebases could cause turtles approaching nesting beaches from the northeast to deviate from their normal migration route.

Magnitude of Impacts—Potential Disturbance Due to Underwater Sound

Potential disturbance-level impacts could extend outside of the Direct AOI via sound propagation, so the geographic extent for this potential impact is considered to be the Direct AOI + Central Stabroek Block. The potential for acoustic disturbance impacts on marine turtles is considered **Episodic** for impulsive sound activities (VSP and pile driving) during the drilling and installation stage and **Continuous** for non-impulsive activities (e.g., vessel operations, FPSO operation) during all Project stages. Disturbance-level impacts would be present on a **Medium-term** basis for impulsive activities and on a **Long-term** basis for non-impulsive activities (primarily related to the production operations phase, when sound sources will be present for at least 20 years). The intensity of potential disturbance-level sound impacts is considered to be **Low** for impulsive sound activities (based on the distance to which they could potentially exert a disturbance effect) and **Negligible** for non-impulsive activities (based on the expectation that the associated sound levels would not be expected to result in a measurable change in behavior and—if so—only within a localized area. This results in magnitude ratings of **Small** for impulsive sound activities and **Negligible** for non-impulsive sound activities, as summarized in Table 7.7-8.

[30] Sound levels expressed in dB in water are not the same as sound levels expressed in dB in air due to differences in the reference level and impedance of the two media. For sounds in water, the reference level is expressed as "dB re 1 µPa," referring to the relative amplitude of a sound wave to a reference pressure of 1 µPa (the reference level for sounds in water) (Bradley and Stern, 2008).

Table 7.7-8: Magnitude Ratings for Disturbance from Anthropogenic Underwater Sound

Stage	Resource—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Drilling and Installation (impulsive sound activities)	Marine turtles—disturbance from sound exposure	Direct AOI + Central Stabroek Block	Low	Episodic	Medium-term	Small
Drilling and Installation Production Operations (non-impulsive sound activities)	Marine turtles—disturbance from sound exposure	Direct AOI + Central Stabroek Block	Negligible	Continuous	Long-term	Negligible
Decommissioning (non-impulsive sound activities)	Marine turtles—disturbance from sound exposure	Direct AOI + Central Stabroek Block	Negligible	Continuous	Medium-term	Negligible

Impact Significance—Potential Disturbance from Anthropogenic Underwater Sound

Based on the magnitude of impact and resource sensitivity ratings described above, the pre-mitigation significance rating for potential disturbance impacts on marine turtles is **Negligible**.

7.7.3.5. Characterization of Impacts—Exposure to Permitted Discharges

Magnitude of Impact—Exposure to Permitted Discharges

The Project will involve routine, permitted effluent discharges to the sea. These discharges will begin during the development well drilling and FPSO/SURF installation stages and continue through the production operations stage and into the decommissioning stage. As described in Chapter 2, Description of the Project, and Section 6.4.3, Impact Assessment—Marine Water Quality, these discharges will be treated (as needed) in accordance with good international oilfield practice. Furthermore, marine turtles will likely be transient in the PDA and the duration of their exposure to any discharges is expected to be very limited. Any potential impacts would be expected to be acute and recovery would be expected to occur quickly after the affected individual(s) exit the mixing zone. As such, the intensity of potential impacts on marine turtles from exposure to permitted discharges is considered **Negligible**. Impacts would occur within the **Direct AOI** (PDA) and would be **Continuous** and **Long-term**. Accordingly, the magnitude of impact is **Negligible** (Table 7.7-9).

Table 7.7-9: Magnitude Ratings for Potential Impacts from Permitted Discharges

Stage	Resource—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
All Project Stages	Exposures to permitted discharges	Direct AOI	Negligible	Continuous	Long-term	Negligible

Impact Significance—Exposure to Permitted Discharges

Based on the magnitude of impact and resource sensitivity ratings described above, the pre-mitigation significance rating for potential toxicological effects on marine turtles from exposure to permitted discharges is **Negligible**.

7.7.3.6. Characterization of Impacts—Artificial Lighting

Magnitude of Impacts—Artificial Lighting

There will be artificial lights in the PDA from various vessel types and Project features, most significantly the FPSO, and the amount of light in the PDA will vary between stages of the Project. Marine turtles are known to be sensitive to artificial light primarily when in close proximity to nesting beaches, because artificial light in the nearshore environment or along the shoreline can cause a variety of potential impacts on the behavior of nesting turtles and hatchlings including reduced nesting rates, premature abandonment of nests/interruption of the egg laying process, and disorientation of hatchlings and adults (Witherington and Martin 2003; NOAA 2014). At no point will the offshore light from the FPSO affect nesting marine turtles (or hatchling turtles making their way from their nest to the sea) since the PDA is located 200 kilometers (124 miles) offshore and the light from the PDA will not be visible from the shore where turtle-nesting activities occur. Based on the definitions for impact intensity presented in Table 7.7-5 above, the intensity of impacts on marine turtle nesting and immediate post-hatching dispersal from Project-related lighting is therefore considered **Negligible**. Impacts would occur within the **Direct AOI** (PDA) and would be **Continuous** and **Long-term**. This yields a magnitude rating of **Negligible** for the coastal environment (Table 7.7-10).

Many studies have demonstrated the impact of onshore lighting on the behavior of nesting marine turtles and hatchlings (attraction, disorientation, nesting abandonment or disruption, etc.) but the effects of artificial light in the offshore environment on marine turtles are not well understood. A recent acoustic-tagging study demonstrated that light is an important navigational cue once hatchlings enter the water and the presence of artificial light in the nearshore environment can affect the swimming and orientation behavior of hatchlings by attracting them towards the artificial light source and sometimes triggering circling behavior around the light source (Thums et al. 2016). These alterations in behavior can cause disorientation, increased energy expenditure, and increased vulnerability to predation (Thums et al. 2016). If nesting turtles and hatchlings are disoriented on land and in the nearshore environment, they may also experience similar effects in the offshore environment; however, it is likely that these effects would only occur at the surface in the immediate vicinity of the light source. Based on the definitions for impact intensity presented in Table 7.7-5 above, the intensity of impacts on

marine turtles from Project-related lighting in the offshore environment is considered **Low**. Impacts would occur within the **Direct AOI** (PDA) and would be **Continuous** and **Long-term**. This yields a magnitude rating of **Small** for impacts of artificial lighting on marine turtles in the offshore environment (Table 7.7-10).

Table 7.7-10: Magnitude Ratings for Potential Impacts from Artificial Lighting

Stage	Resource—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
All Project Stages	Impact on nesting turtles and immediate post-dispersal hatchlings from nearshore and coastal artificial lighting	Direct AOI	Negligible	Continuous	Long-term	Negligible
All Project Stages	Impact on turtles in the offshore environment from artificial lighting from vessels and the FPSO	Direct AOI	Low	Continuous	Long-term	Small

Impact Significance— Exposure to Artificial Lighting

Based on the magnitude of impact and resource sensitivity ratings described above, the pre-mitigation significance ratings for potential impacts on marine turtles from exposure to artificial lighting are **Negligible**.

7.7.3.7. Characterization of Impacts—Displacement from Habitat as a Result of Disturbance

Magnitude of Impact—Displacement from Habitat as a Result of Disturbance

During the Project life cycle (at least 20 years), levels of human activity (e.g., vessel traffic, equipment, and materials in the water) will be higher than the low levels that currently exist in the offshore portion of the AOI. Marine turtles are sensitive to anthropogenic activities on and off (i.e., at sea) land, and disturbance in the offshore environment would likely cause some level of avoidance of, and thus displacement from, impacted areas by individual turtles (e.g., McClellan and Read 2009). For example, vessel traffic has been shown to alter marine turtle behavior and displace individuals from areas where vessels are active (McCelland and Read 2009). Typically, affected turtles are displaced short distances and if an affected turtle's home range overlaps with the displacement area, the displaced turtle will usually return a short while later. Little is known about marine turtle avoidance behavior during migrations, but they would be expected to be at similar risk for alteration of course during migration compared with other lifestages. The primary impact from avoidance behavior, particularly when the displacement is confined to a relatively small area such as the PDA, is increased energy expenditure.

Based on available information on marine turtles in the PDA and the surrounding region, low numbers of marine turtles are expected to occur in the PDA and, when they do occur there, they are expected to be transiting through the PDA while en route to preferred habitats. The PDA is

not known to contain any habitats that are regularly used by marine turtles during any lifestage. As such, the level of displacement potentially caused by Project activities is expected to be low.

Project activities that could disturb marine turtles transiting the PDA will decrease during the production operations phase, so potential disturbance-related impacts on marine turtles are expected to decrease with time. There will be a small increase in human and vessel activity during decommissioning compared to the production operations phase, but that increase will be of relatively short duration and it will not rise to the same level of activity associated with drilling and installation. Project-related vessel traffic between the shorebases and PDA could cause a limited amount of additional avoidance by turtles passing through the PDA or the marine transit corridor compared with current conditions. However, the transit corridor is a very small fraction of the geographic range of the five marine turtle species occurring in Guyana so temporary displacement of individuals from this area due to vessel or other Project-related disturbance is expected to be inconsequential for the marine turtle populations in the region.

Based on the definitions for impact intensity presented in Table 7.7-5 above, the intensity of impacts on marine turtles from displacement is considered **Negligible**. Impacts would occur within the **Direct AOI** and would be **Continuous** and **Long-term**. This yields a magnitude rating of **Negligible** for impacts of displacement on marine turtles in the offshore environment (Table 7.7-11).

Table 7.7-11: Magnitude Ratings for Potential Impacts from Habitat Displacement

Stage	Resource—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
All Project Stages	Habitat displacement	Direct AOI	Negligible	Continuous	Long-term	Negligible

Impact Significance—Habitat Displacement

Based on the magnitude of impact and resource sensitivity ratings described above, the pre-mitigation significance rating for potential impact on marine turtles from habitat displacement is **Negligible**.

7.7.4. Management Measures—Marine Turtles

The embedded controls integrated into the Project design and operational procedures constitute the practicable best measures that are available to reduce the significance of potential impacts on marine turtles. Table 7.7-12 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 7.7-12: List of Embedded Controls and Monitoring Measures

Embedded Controls
When non-aqueous drilling fluid (NADF) is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.

Employ trained MMOs during the conduct of seismic-related activities.
Conduct a continuous observation of a mitigation zone (500 meters [1,640 feet] around the sound source) to verify whether it is clear of marine mammals and marine turtles before commencing sound producing seismic operations. Do not commence sound-producing seismic operations (including soft starts) if marine mammals or turtles are sighted within the mitigation zone during the 30 minutes prior to commencing sound-producing operations in water depths less than 200 meters (656 feet), or 60 minutes prior to commencing sound-producing operations in water depths greater than 200 meters (656 feet).
Where practicable, equip sound-making devices with silencers or mufflers that are enclosed, and/or use soft-start procedures (e.g., for pile driving, vertical seismic profiling, etc.) to reduce noise to levels that do not cause material harm or injury to marine species
Adhere to the JNCC guidelines (2017) during the conduct of seismic-related activities.
During pile-driving activities, gradually increase the intensity of hammer energy to allow sensitive marine organisms to vacate the area before injury occurs (i.e., soft starts).
For all vessel effluent discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage), comply with International Maritime Organization / International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 milligrams per liter (mg/L) on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored, and the discharge meets the noted specification.
Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C (5.4°F) at 100 meters (approximately 328 feet) from discharge point.
Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals
Monitor residual chlorine concentration of sewage discharges form the FPSO monthly to stay is below 0.5 mg/L in accordance with MARPOL 73/78 regulations.
Perform daily visual inspections on the FPSO of discharge points to verify that there are no floating solids or discoloration of the surrounding waters.
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.
Implement chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances and consider the Offshore Chemical Notification Scheme as a resource for chemical selection in Project production operations. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes; • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.
For effluent released from the onboard sewage treatment plant, comply with aquatic discharge standards in accordance with MARPOL 73/78 regulations.
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter particle size or less) prior to discharge.

Confirm there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge. Perform daily inspections to verify no visible sheen from discharge of cooling water.
Treat bilge water in accordance with MARPOL 73/78 to comply with an oil-in-water content of less than 15 parts per million (ppm), as applicable.
Where reasonably practicable, direct lighting on FPSO and major Project vessels to required operational areas rather than at the sea surface or skyward. Adhere to maritime safety regulations/standards for lighting on vessels.
Mitigation Measures
Following start-up of production operations, implement a program to characterize effluent water discharges from the FPSO and conduct an environmental risk assessment based on the characterization data. As appropriate based on the results of the environmental risk assessment, implement additional treatment options, if warranted and feasible.
Monitoring Measures
Continue to monitor marine mammals, riverine mammals, and marine turtles on the basis of incidental detections by MMOs and passive acoustic monitoring during seismic exploration activities.
Prior to and post-drilling, a remotely operated vehicle will take pictures of the area immediately surrounding the well location to monitor for marine water quality impacts.
Monitor daily during drilling to confirm that end of well maximum weighted mass ratio averaged over all well sections drilled using non-aqueous base fluid shall not exceed 6.9 percent wet weight base fluid retained on cuttings.
Monitor daily produced water discharge volume.
Measure oil and grease content of produced water (grab sample once per day).
Perform daily inspections to verify no visible sheen from discharge of cooling water.
Monitor discharge temperature of cooling water and produced water to avoid increases in ambient water temperature of more than 3°C (5.4°F) at 100 meters (approximately 328 feet) from point of discharge.
Use load-monitoring system in the FPSO control room to support FPSO offloading.
Monitor pressure and temperature of subsea wells and manifolds by a control system on the FPSO to detect and prevent leaks.
Monitor chlorine concentration of treated sewage discharges.
Perform daily visual inspection of discharge points to verify absence of floating solids or discoloration of the surrounding waters.
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book.
Perform oil in water content (automatic) monitoring of bilge water to comply with 15 ppm MARPOL 73/78 limit and record in Oil Record Book.
Record estimated volume of ballast water discharged and location (per ballasting operation).

Table 7.7-13 summarizes the assessment of potential pre-mitigation and residual Project impacts on marine turtles. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the marine turtle-specific methodology described in Sections 7.7.3.2 through 7.7.3.7.

Table 7.7-13: Marine Turtles—Pre-Mitigation and Residual Impact Significance Ratings

Stage	Potential Impact	Magnitude Rating	Sensitivity Rating	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Well Drilling (impulsive sound activities) FPSO/SURF Installation (impulsive sound activities)	Auditory injury from sound exposure	Negligible	High	Negligible	None, other than implementation of embedded controls (e.g., soft-start procedures for VSP and pile driving)	Negligible
All Project stages (non-impulsive sound activities)	Auditory injury from sound exposure	Negligible	High	Negligible	None	Negligible
Development Well Drilling (impulsive sound activities) SURF Installation (impulsive sound activities)	Disturbance from sound exposure	Small	Low	Negligible	None, other than implementation of embedded controls (e.g., soft-start procedures for VSP and pile driving)	Negligible
All Project stages (non-impulsive sound activities) from operating FPSO and marine vessel operations	Disturbance from sound exposure	Negligible	Low	Negligible	None	Negligible

Stage	Potential Impact	Magnitude Rating	Sensitivity Rating	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project Stages	Exposures to permitted discharges (discharges containing various chemical substances, plus elevated temperature during production operations)	Negligible	High	Negligible	None	Negligible
	Impact on nesting turtles and immediate post-dispersal hatchlings from nearshore and coastal artificial lighting	Negligible	High	Negligible	None	Negligible
	Disturbance to turtles in the offshore environment from artificial lighting from vessels and the FPSO	Small	Low	Negligible	None	Negligible
	Habitat displacement as a result of avoidance behavior	Negligible	High	Negligible	None	Negligible

7.8. MARINE FISH

7.8.1. Administrative Framework—Marine Fish

Table 7.8-1 summarizes the legislation, policies, or treaty commitments that are specifically relevant to the assessment of potential impacts on marine fish.

Table 7.8-1: Legislation, Policies, or Treaty Commitments—Marine Fish

Title	Objective	Relevance to the Project
Legislation		
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013; the Wild Birds Protection Act, 1987; and the Species Protection Regulations, 1999)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a framework to address the national goals for wildlife protection, conservation, and management. The Act also provides recommendations on measures for the protection of threatened ecosystems and habitats, and advises on measures for conservation of biological diversity.
Fisheries Act, 2002	Regulates fishing and related activities in Guyana territorial waters.	Section 33(1) of the Fisheries Act authorizes the prohibition and/or regulation of deposition or discharge of substances harmful to fish.
International Agreements Signed/Acceded by Guyana		
International Maritime Organization Agreements	The IMO administers a number of global environmental conventions, agreements, and commitments such as International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978, on ship-generated wastes; Ballast Water Convention; London Convention.	Contracting parties to the convention are also required to protect and preserve rare or fragile ecosystems and habitats of depleted, threatened, or endangered species; and develop technical and other guidelines for the planning and environmental impact assessments of important development projects.
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (Guyana acceded and ratified in 2010)	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection of the marine environment, especially from possible pollution.
Convention on Biological Diversity (Guyana signed in 1992 and ratified in 1994)	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Encourages Project design and execution to protect and conserve biological diversity.

7.8.2. Existing Conditions—Marine Fish

Guyana's marine fish community inhabits a large and ecologically diverse marine area, from shallow, turbid, coastal waters to the deep, clear, open ocean. The life cycles of many of the fish species present in the community exemplify the ecological connectivity among the mangroves, estuaries, and offshore zones, because many fish species are dependent on different habitats at specific life stages or occur in more than one habitat type. Several species that occur in the inshore and offshore zones as adults are dependent on coastal mangroves and estuaries as juveniles, particularly drums, croakers, marine catfishes, and snappers. Catfishes occur in the mangroves, estuaries, and oceanic waters as adults. Some other species, including snooks and tarpon, may occur occasionally in the ocean, but are specifically adapted to completing their entire life cycles in mangrove-lined estuaries (MOA 2013). Farther offshore, near the interface of the turbid North Brazil Current with oceanic water, the fish community is more complex, consisting of pelagic, highly migratory species such as tunas, jacks, and mackerels in the upper water column and a diverse groundfish community, including snappers and groupers, in the demersal zone (lowest section of the water column, near the seafloor) (MOA 2013). Sharks are found across the continental shelf and in deeper oceanic waters.

Prior to 2015, much of the available information about marine fishes offshore Guyana was known from studies of commercial landings, or inferred studies of similar locales. Beginning in 2015, EEPGL commissioned a program of collecting incidental observations of marine fish from PSOs engaged in marine mammal-focused surveys offshore Guyana. EEPGL subsequently commissioned a series of surveys targeted at fish in the Stabroek Block and in the area between the Stabroek Block and the Guyana coast from 2017 to 2019. These surveys were conducted in separate zones within this area by teams of international and Guyanese fish experts, as follows:

- Dry Season, Study Year One: September–October 2017
- Wet Season, Study Year One: April 2018
- Dry Season, Study Year Two: December 2018 through early February 2019
- Wet Season, Study Year Two: May–June 2019

The targeted fish surveys covered the following zones using the techniques listed below:

- Southern Stabroek Block, using deepwater traps and pelagic longlines;
- Continental shelf, using trawls and longlines;
- Nearshore habitats, using seine nets and cast nets; and
- Estuaries, using electrofishing equipment.

An ichthyoplankton component was added in December 2018 to assess diversity and distribution of early life stages of marine fish. This component was carried out concurrently with the other sampling efforts in the four zones identified above.

The results of these targeted fish surveys are presented in ERM (2018) for the first study year and in Appendix M, Nearshore and Offshore Fisheries Study Summary, for the second study year. A comprehensive list of marine fish known from Guyana's waters, based on the

results of these fish studies combined with historical literature, is included as Appendix R, List of Marine Fishes in Guyana.

7.8.2.1. Targeted Surveys of Deepwater and Offshore Pelagic Fish Community

Inclement weather prevented sampling of the deepwater zone in the second dry season of the study, and although deepwater traps were deployed during the second wet season, no species were captured during the deepwater sampling effort. Consequently, the discussion of deepwater and offshore pelagic fish community data is derived from sampling conducted in the Stabroek Block in the first study year (i.e., October 2017 and April 2018). Compared to the shallower environments, Guyana's deepwater environment appears to be lacking in numbers or species variety. The deepwater and offshore pelagic fish surveys during the first study year sampled pelagic fish and demersal fish at several locations on the continental slope (Figure 7.8-1). Demersal fish were sampled between depths of 800 and 1,500 meters (approximately 2,600 and 4,900 feet). These samples documented three deepwater species: Robinson's hagfish (*Myxine c.f. robinsorum*), sharp-tailed eel (*Coloconger meadi*), and lanternfish (Myctophidae) (ERM 2018). According to Guyana's Centre for the Study of Biodiversity, Robinson's hagfish and sharp-tailed eel were both new species records for Guyana at the time. Robinson's hagfish was the most abundant of the deepwater fishes caught in the study, accounting for over 90 percent of the total catch.

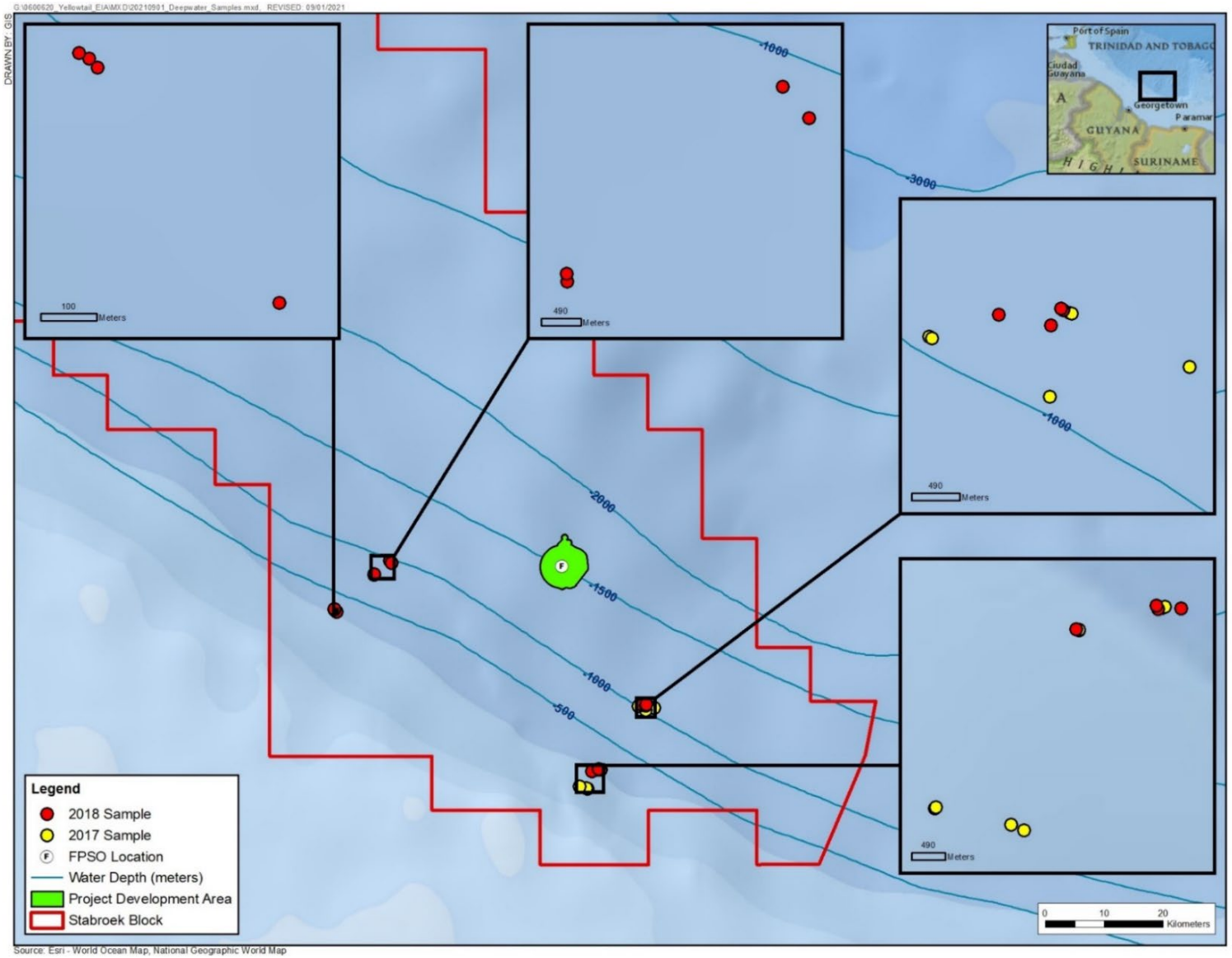


Figure 7.8-1: Locations of Deepwater and Offshore Pelagic Fish Sampling Stations in Stabroek Block during the First Year of EEPGL-Commissioned Study

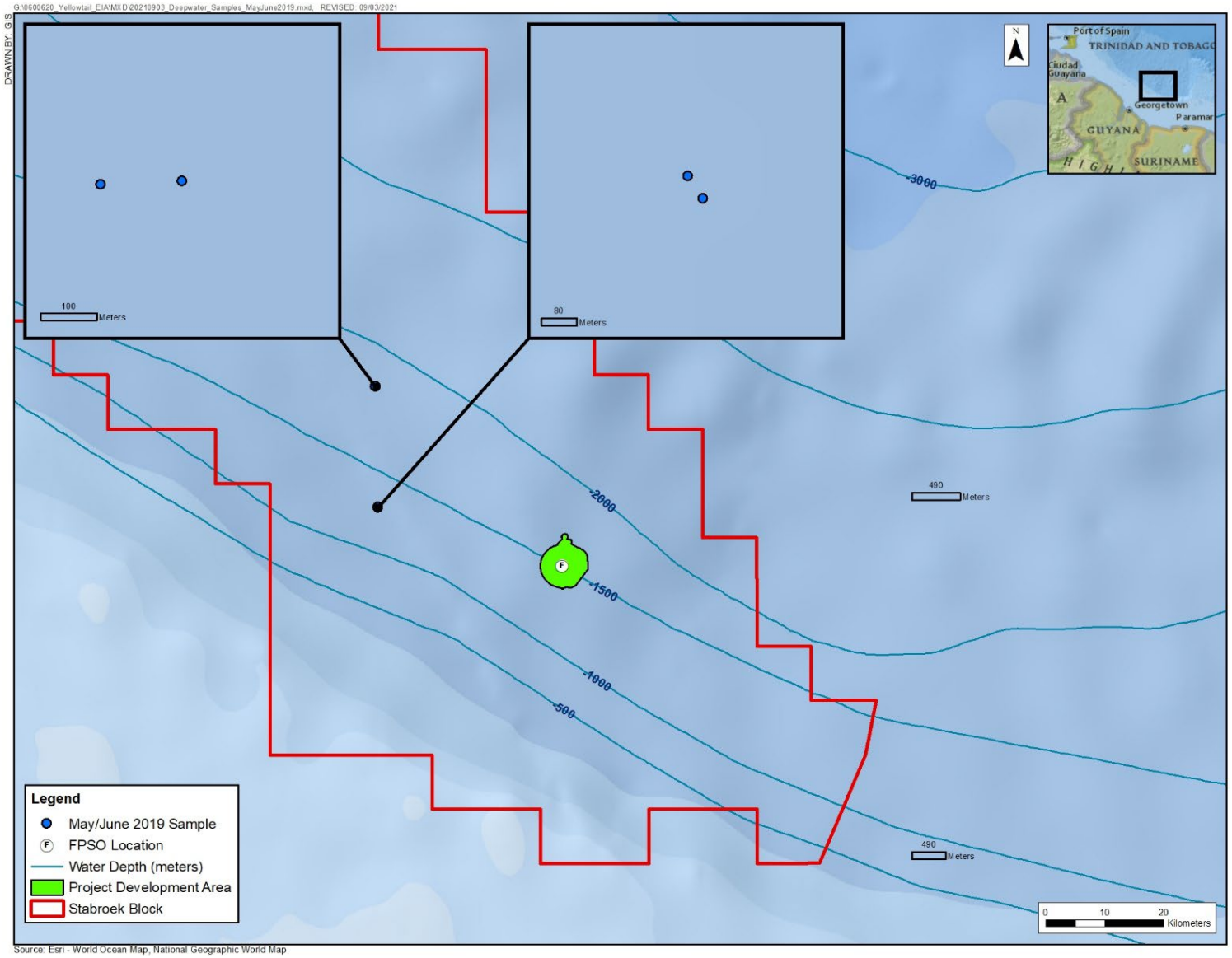


Figure 7.8-2: Locations of Deepwater and Offshore Pelagic Fish Sampling Stations in Stabroek Block during the Second Year of EEPGL-Commissioned Study

Robinson's hagfish was most common near the 1,000-meter (approximately 3,300-foot) isobath. No fish were captured deeper than 1,000 meters (approximately 3,300 feet). These are the only species of demersal fishes to have been captured and positively identified from the Stabroek Block to date, although other taxa have been incidentally documented from deepwater images taken during various non-fish targeted surveys, which include:

- A study of deepwater habitats using remotely operated vehicles (ROVs) and drop cameras produced images of putative grenadiers (Macrouridae), skates/rays, and tripodfish (*Bathypterois* sp.) within the Stabroek Block, although none were identifiable to species (ERM 2018); and
- In 2019, Fugro published an investigation of anomalous so-called *hard seafloor features* (HSFs) within and near the vicinity of the Payara Subsea PDA (Fugro 2019). This study captured a photo of an eelpout that was provisionally identified as possibly a member of the genus *Lycodonus.*

Population studies for fish in deep-sea environments (demersal) are scarce. The low productivity of deep-sea environments compared to more shallow water environments is thought to limit reproductive potential of deepwater organisms in general, so the low numbers of fish in the demersal samples are expected.

Pelagic sampling of the top 50 meters (approximately 164 feet) of the water column within the Stabroek Block has documented only one species of fish, dolphinfish (*Coryphaena hippurus*) to date, although other oceanic/pelagic species that are known from Guyana's continental shelf, including bigeye scad (*Selar crumenophthalmus*), king mackerel (*Scomberomorus cavalla*), and various species of sharks (*Carcharinus* spp.), could also occur in the pelagic zone of the block. Smalleye smoothhound (*Mustelus higmani*) is known to occur as deep as the southern edge of the Stabroek Block, and southern red snapper (*Lutjanus purpureus*) support a small, targeted, deepwater trap fishery that reportedly extends to the edge of the continental shelf. All of these species were captured at the outer-continental shelf stations during the fish study and should be considered as possibly occurring in the PDA.

In the summer of 2011, several islands in the eastern Caribbean (e.g., Anguilla, Antigua and Barbuda, Barbados, British Virgin Islands, Guadeloupe, Martinique, St. Lucia, St. Maarten/ St. Martin) experienced large amounts of sargassum washing ashore. In 2012 and 2014, Barbados, Guadeloupe, Dominica, Antigua and Barbuda, St. Croix, and Puerto Rico reported "moderate" amounts of sargassum coming ashore. The sargassum consisted of two species: common gulfweed (*Sargassum natans*) and broad-toothed gulfweed (*Sargassum fluitans*) (CRFM undated). Similar episodes were reported across the Caribbean region again in 2018. A large amount of sargassum was also documented in the Stabroek Block in 2015. Subsequent analysis of satellite imagery revealed that although sargassum densities were unusually high offshore Guyana in 2015, sargassum concentrations fluctuate annually and have a seasonal peak between April and September (Palandro 2016).

The presence of such large amounts of sargassum is significant from a fish biodiversity perspective, because sargassum has several important ecological roles related to marine fishes, including:

- Concentrating forage fish that are preyed upon by large pelagic fishes, including juvenile swordfish (*Xiphiaa gladius*), dolphinfish, filefishes, jacks, flying fishes (Exocoetidae), triggerfishes, and various tunas;
- Spawning habitat for flying fish; and
- Habitat for unique fishes and other organisms that spend most or all of their lives in floating mats of sargassum, including the sargassum fish (*Histrio histrio*).

7.8.2.2. Targeted Surveys of Continental Shelf Fish Community

The discussion of continental shelf fish community data is derived from wet- and dry-season sampling conducted across the continental shelf in both study years (September–October 2017 and December 2018–February 2019 for the dry season, and April 2018 and May–June 2019 for the wet season), historical data (see discussion of the Lowe-McConnell [1962] study below), and incidental observations (see Section 7.8.2.3, Additional Surveys). The continental shelf stations sampled during both study years were located in water from 11 to 2,340 meters (approximately 36 to 7,700 feet), although most sites were less than 250 meters (approximately 820 feet) deep. The continental shelf stations sampled during the first year of study (Figure 7.8-3) and second year of study (Figure 7.8-4) were located in water from 11 to 2,340 meters (approximately 36 to 7,700 feet), although most sites were less than 250 meters (approximately 820 feet) deep. The continental shelf was the most species-rich environment sampled during this assessment (compared to nearshore and deepwater environments), accounting for 109 fish species in the first study year (ERM 2018) and 92 species in the second study year (Appendix M, Nearshore and Offshore Fisheries Study Summary).

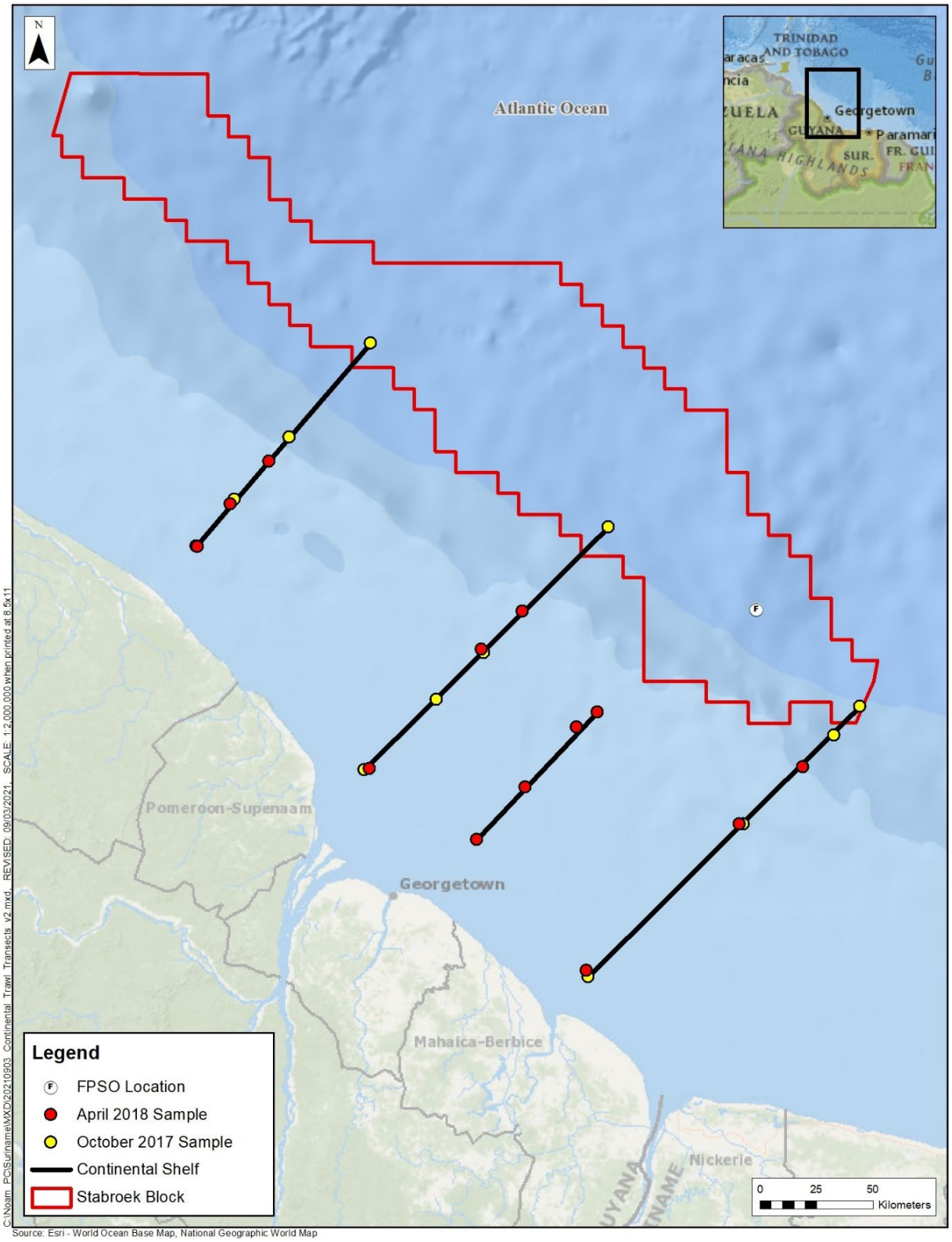
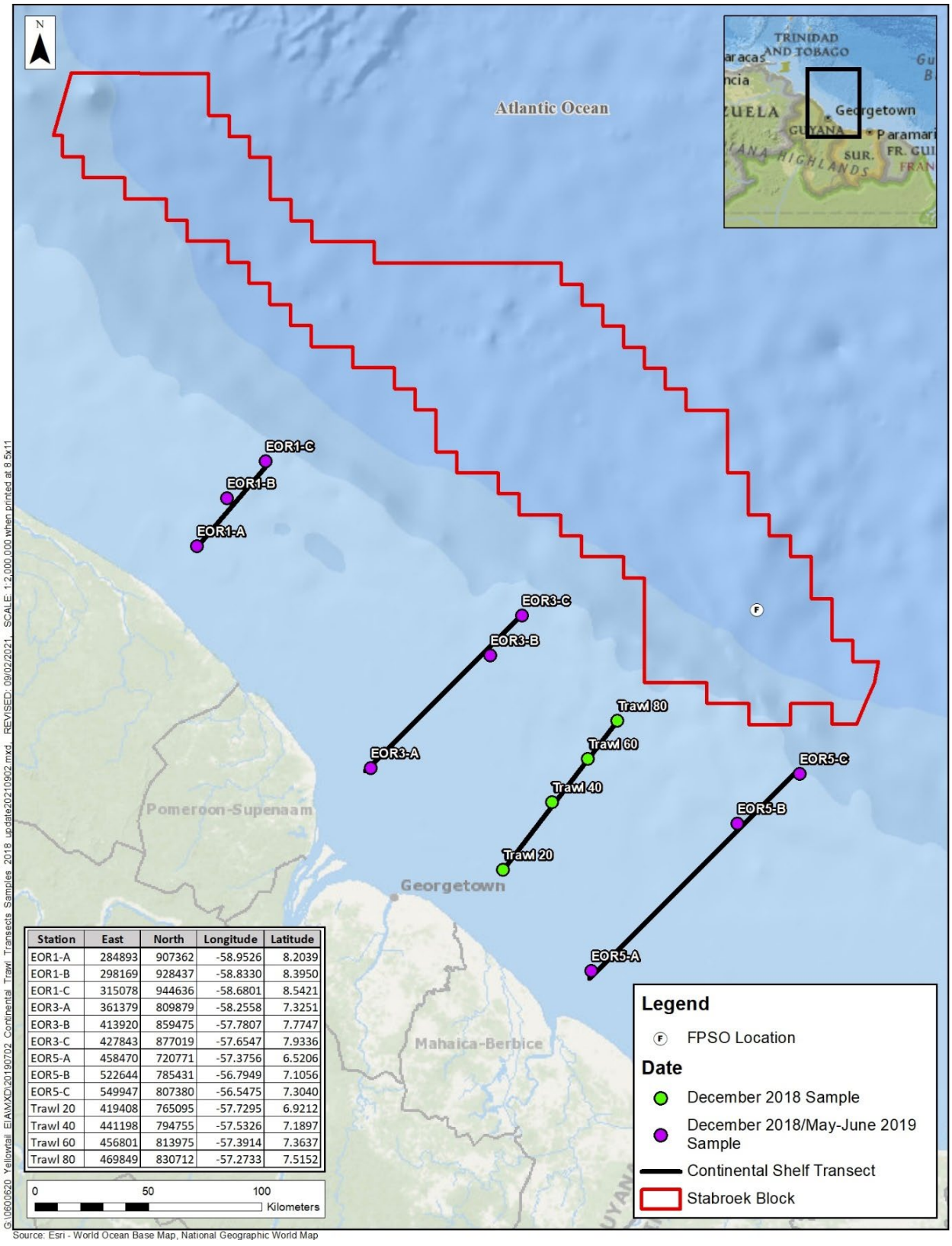


Figure 7.8-3: Location of Continental Shelf Fish Sampling Stations during the First Year of EEPGL-Commissioned Study



Station	East	North	Longitude	Latitude
EOR1-A	284893	907362	-58.9526	8.2039
EOR1-B	298169	928437	-58.8330	8.3950
EOR1-C	315078	944636	-58.6801	8.5421
EOR3-A	361379	809879	-58.2558	7.3251
EOR3-B	413920	859475	-57.7807	7.7747
EOR3-C	427843	877019	-57.6547	7.9336
EOR5-A	458470	720771	-57.3756	6.5206
EOR5-B	522644	785431	-56.7949	7.1056
EOR5-C	549947	807380	-56.5475	7.3040
Trawl 20	419408	765095	-57.7295	6.9212
Trawl 40	441198	794755	-57.5326	7.1897
Trawl 60	456801	813975	-57.3914	7.3637
Trawl 80	469849	830712	-57.2733	7.5152

Figure 7.8-4: Location of Continental Shelf Fish Sampling Stations during the Second Year of EEPGL-Commissioned Study

The most complete historical data on marine fish in Guyana's territorial waters come from a 2-year trawl survey in 1958 and 1959. The survey consisted of 35 cruises lasting 4 to 11 days each, and included data from 1,070 stations comprising 2,246 fishing hours (Lowe-McConnell 1962). The study documented the presence of 213 species of fish, comprised primarily of drums/croakers, catfishes, jacks, grunts, and snappers. In general, this study described catfishes, drums, jacks, and grunts as dominating the nearshore zone, and snappers and various other demersal species, including some that are typical of clearwater tropical reef systems, as more abundant at deeper sites farther offshore. The results of the EEPGL-commissioned fish study from the continental shelf are largely consistent with these findings. In the first year of the EEPGL-commissioned study, the most diverse groups consisted of sea catfishes, including gillbacker catfish (*Sciades parkeri*), curass (*Sciades proops*), highwaterman catfish (*Hypophthalmus edentatus*); croakers/seatrouts, including bangamary (*Macrodon ancylodon*), white bashaw (*Cynoscion acoupa*), sea trout (*Cynoscion virescens*); and snappers and grunts, represented chiefly by banded grunt (*Conodon nobilis*), Caesar grunt (*Haemulon carbonarium*), mutton snapper (*Lutjanus analis*), lane snapper (*Lutjanus synagris*), and southern red snapper (Figure 7.8-5). The second year of the study was similar in terms of the taxonomic composition of the continental shelf samples. The most diverse families in the samples included Sciaenidae (drums and croakers, 13 species), Haemulidae (grunts, 7 species), Ariidae (sea catfishes, 4 species), Triglidae (sea robins, 4 species), and Lutjanidae (snappers, 4 species).

Seasonal influences on biomass and species composition across the continental shelf were markedly different between the first and second years of the EEPGL-commissioned fish study in several respects. Total biomass was much higher during the first year than during the second year in both seasons. Biomass was highest in the dry season during the first year, but highest in the wet season during the second year. Large predatory species (e.g., sharks, mackerels, barracudas, dolphinfish, jacks) were also more commonly encountered during the first year (especially sharks) than in the second year, and most commonly encountered in the dry season. Water quality may have played a role in the differences between years. Maximum measured water temperatures in the dry season reached approximately 35°C (95°F in the second year's dry season, approximately 5°C (41°F) higher than in the first year. These temperatures may have been sufficiently high to cause some species to seek cooler water. Very few marine fish prefer water temperatures above 32°C (89.6°F), so water temperatures during the second year's dry season probably had some effect on fish distributions; however, temperatures above 32°C (89.6°F) did not occur frequently, so thermal effects on fish distribution were probably limited. Dissolved oxygen levels were also conspicuously low during the wet season in the second study year, with concentrations at the seafloor below 2.0 mg/L at 4 of the 13 sampling stations. This is below the optimum range for most marine fishes, and may partially explain the apparent scarcity of large fishes during this period. Low dissolved oxygen concentrations were more widespread in the second wet season than high temperatures were in the second dry season, so dissolved oxygen concentrations likely had a more significant effect on fish distribution than temperature across the continental shelf during the second study year.

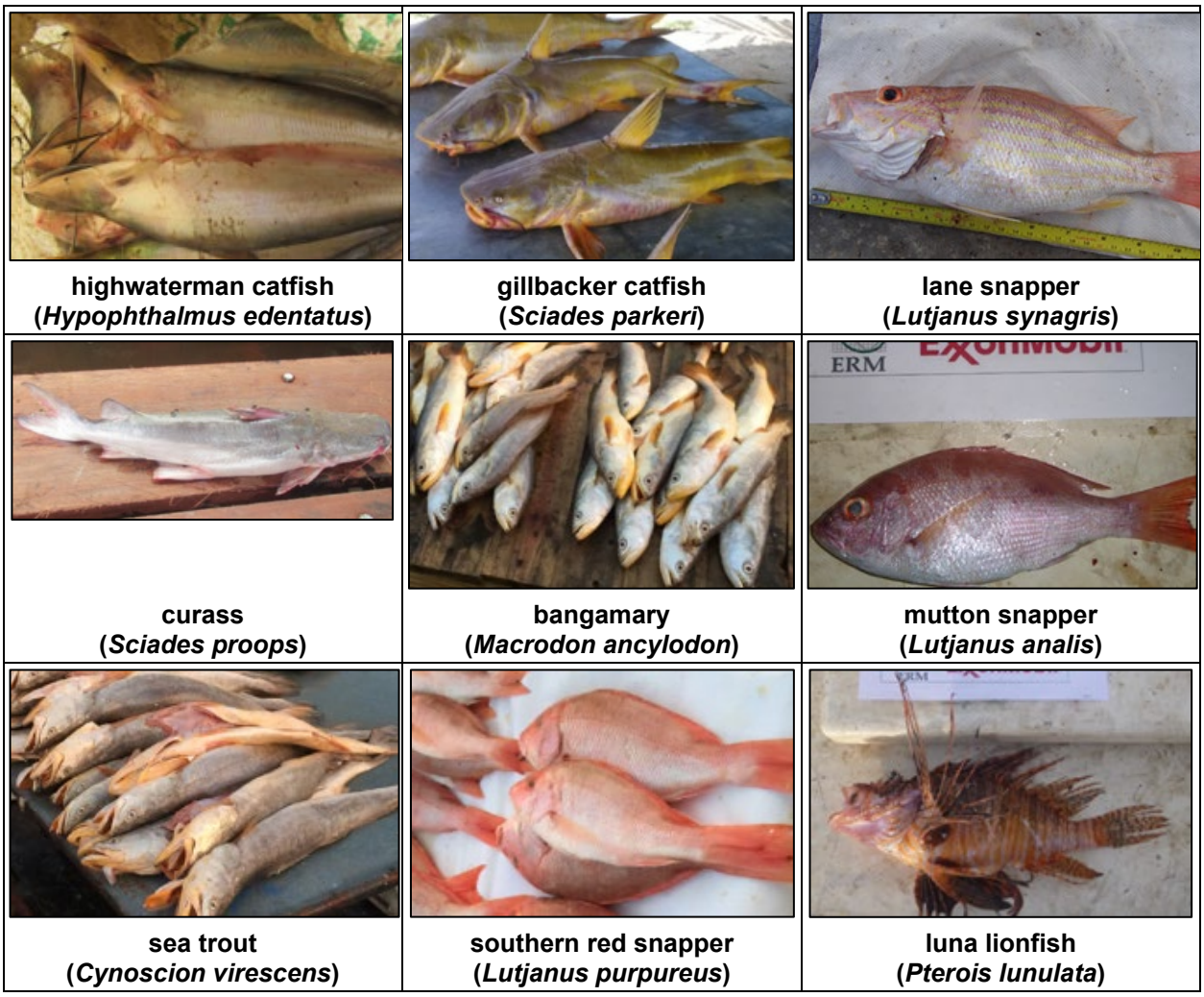


Figure 7.8-5 Characteristic Fishes from Guyana's Continental Shelf

Several comments were received during the EIA disclosure process indicating that fish catches had declined significantly in recent years. Although the decline in biomass between the first and second years of the EEPGL-commissioned fish study (Appendix M, Nearshore and Offshore Fisheries Study Summary) is consistent with these comments, more data would be needed to scientifically establish whether fish abundance is generally declining over time. As described in Section 8.1.2, Existing Conditions—Socioeconomic Conditions, several possible causes for perceived declines in catches over the last several years have included interference with fishing activities by sargassum, inclement weather, unsustainable/illegal fishing practices, and more recently, COVID-19-related declines in fishing effort. Some commenters implied a connection between increased oil and gas-related activity and declining catches, but declining catches have been observed since at least 2013 (see Section 8.1.2), which predates the first commercial oil discovery in Guyanese waters by 2 years. The reports of declining catches also pertain to fisheries that operate mainly on the inner and middle continental shelf (south of EEPGL's development projects) while oil and gas activities to date have been focused in deepwater areas north of the most active fishing zones. These temporal and spatial factors suggest that to the

extent that marine fish production may be experiencing long-term decline, oil and gas activities are not likely to be driving this decline.

Although biomass and species composition in the continental shelf samples varied between the first and second study years, seasonal and spatial distribution of fish species diversity on the continental shelf were remarkably consistent between years. During the second study year, fish diversity was uneven between the transects in the dry season, but relatively consistent in the wet season. The same pattern was observed in the first study year, which suggests that seasonal influxes of freshwater across the continental shelf may obscure the effects of localized differences in physical habitat on the fish community. Species richness also increased at the shallowest sites in the wet season in both years, which provides further evidence of the seasonal influence of freshwater inputs on species richness, especially on the inner continental shelf. The mid- to outer-shelf stations produced the highest number of species in both seasons in both study years, indicating that despite seasonal increases in nearshore diversity in the wet season, the highest fish diversity is consistently found on the mid- to outer-continental shelf. Visual observations made by the field team during the second study year indicate that the portion of the continental shelf between 60 to 100 kilometers (37 to 62 miles) offshore is an area of transition from the mixture of "blackwater"[31] and highly turbid silt-laden water nearshore to clearer waters more characteristic of offshore conditions, an observation supported by the turbidity data collected from the continental shelf stations.

Based on comparisons with species lists from nearby countries, Lowe-McConnell determined that about 50 percent of Guyana's marine fish species were widely distributed coastal species, about 10 percent were clear-water associated species more typical of the Caribbean Islands, about 5 percent were more southerly species typical of the Brazilian coast, and the balance were habitat generalists with no defined regional habitat associations. Lowe-McConnell also noted that the North Atlantic Continental Shelf is continuous from the Gulf of Mexico to Brazil and that there were no major barriers to migration through this area, so Guyana's marine fish community would be expected to have many species in common with other countries in the region. This finding is consistent with the findings of the EEPGL-commissioned continental shelf fish surveys in both study years.

Lowe-McConnell's study and the continental shelf component of the EEPGL-commissioned fish surveys both documented several species of typically reef-associated fish, although some notable differences between the two studies suggest the clear-water fish community on the outer continental shelf has undergone significant changes in the last half century. Lowe-McConnell's paper on Guyana's fishery resources noted the presence of coral fragments in trawl samples, but described those coral fragments as dead; no living corals were mentioned. As described in Section 7.9.2, Existing Conditions—Marine Benthos, both years of the EEPGL-

[31]The clarity of water flowing out of Guyana's rivers onto the continental shelf is limited by two types of influences. The first is so-called "blackwater" contributions, which come from swamps and other wetlands that characteristically have deep accumulations of organic debris. Water flowing from these areas has a very dark color and low light transmissivity because of high tannin content, but typically has very low suspended solids. The second type has no colloquial name in Guyana, but consists of non-tannic runoff from coastal tributary streams. In the estuaries and nearshore marine environments where both of these types of water mix with oceanic water, water clarity is typically low.

commissioned fish study documented the presence of living hard corals on the continental shelf. The first year of study identified two corals (*Madrepora oculata* and *Solenosmilia variabilis*) at depths of 40 to 90 meters (approximately 131 to 295 feet) on three of the four continental shelf transects (Figure 7.8-3). These species also appeared in trawl samples at the B stations on transects EOR1, EOR3, and EOR5 during the second year of study (Figure 7.8-4), but were most common at depths from 110 to 160 meters (361 to 525 feet) on the outer continental shelf during the second study year. Lowe-McConnell noted the presence of some typically reef-associated fishes in the samples, including butterflyfishes, angelfishes, wrasses, and parrotfishes (Lowe-McConnell 1962). The EEGPL-commissioned study also documented a few reef-associated species, including ocellated moray (*Gymnothorax ocellatus*), French angelfish (*Pomacanthus paru*), and spotfin butterflyfish (*Chaetodon ocellatus*), in the same depth ranges as the living corals, but no parrotfishes or wrasses. Although it is unlikely that significant recovery of Guyana's hard corals has occurred since the time of Lowe-McConnell's study, given the intensity of the trawling activity on the continental shelf, the EEPGL-commissioned study clearly shows that living hard corals do persist on Guyana's continental shelf and that coral-associated fishes occur in these habitats.

The study also documented the exotic luna lionfish (*Pterois lunulata*) and red lionfish (*Pterois volitans*) in the same depth range as the corals and reef-associated native species (Figure 7.8-5). The presence of invasive lionfish in the tropical western Atlantic Ocean and Caribbean Sea has been a topic of conservation concern for more than three decades since they first appeared in southern Florida (FWC 2018) and began threatening native fishes and commercial ground-fisheries (NOAA 2020). The presence of luna lionfish and red lionfish offshore Guyana and the apparently coincident decline of coral-associated fishes offshore may indicate that the invasion is having an effect on Guyana's native fishes. A time series of the expansion of lionfish throughout the Western Atlantic region provided by the U.S. Geological Survey suggested that as of 2017, lionfish had not been found in Guyana, despite having been found in neighboring Tobago and Venezuela (USGS 2021); however, these data are subject to revision, so it is unclear whether the presence of lionfish in the fish study samples represents a novel invasion. Regardless of when the lionfish first arrived in Guyana, luna lionfish were captured again in the December 2018 continental shelf survey, so their presence appears to be persistent.

Pelagic sampling of the continental shelf during the 2017–2018 fish study also documented the importance of the continental shelf as a nursery area for sharks (Figure 7.8-6). Spinner shark (*Carcharinus brevipinna*) comprised a significant component of the longline samples during the wet and dry seasons. Spinner sharks accounted for nearly 20 percent of the total abundance in the 2017 longline samples from the continental shelf, second only to the spearfish remora (*Remora brachyptera)*, which are often associated with sharks and other large pelagic marine animals. No spinner sharks were positively identified in the 2018 samples, but juvenile *Carcharinus* that were too small to identify comprised 50 percent of the total longline catch on the continental shelf in 2018, possibly indicating a seasonal component to the value of the area as nursery habitat for the species. Sharks occurred in the second-year catches from the continental shelf, but were not as common as in the first year. Although the sharks in the study

were identified in the field as spinner sharks, field identification of *Carcharinus* species (especially of immature specimens) can be very difficult. A recent genetic study of sharks in Guyanese fish markets did not document spinner sharks, but did identify the very similar smalltail shark (*C. porous)* and blacktip shark (*C. limbatus)*, which together comprised over 25 percent all samples in the study (Kolman et al. 2017); accordingly, the identification of the sharks in the 2017–2018 fish study should be viewed as provisional. Regardless of the species, the presence of large numbers of immature *Carcharinus* sharks is significant both in terms of the ecology of the area—as sharks are apex predators on the continental shelf—and in terms of fishery management. Sharks are a target species for the demersal longline (locally referred to as Cadell lines) fishery, and shark stocks are well-known to be highly sensitive to fishing pressure due to their low reproductive success rates and long generation times. There are no official management plans or quotas in place for the Guyanese shark fishery, so the fishery may be susceptible to over-exploitation, particularly if large numbers of juveniles are being removed from the population before having the opportunity to reproduce.

Figure 7.8-6: Juvenile *Carcharinus* Sharks from Guyana's Continental Shelf, March 2018

7.8.2.3. Additional Surveys of Deepwater and Offshore Pelagic Fish and Continental Shelf Fish Communities

Additional information on pelagic species within the PDA is available from visual observations made during EEPGL-commissioned PSO activities in the southeastern half of the Stabroek Block and surrounding offshore and continental shelf region since 2015 (Figure 7.8-7). From these opportunistic observations made since 2015, a total of 31 fish taxa were assessed to be present in the Stabroek Block at least on an occasional basis (Table 7.8-2).

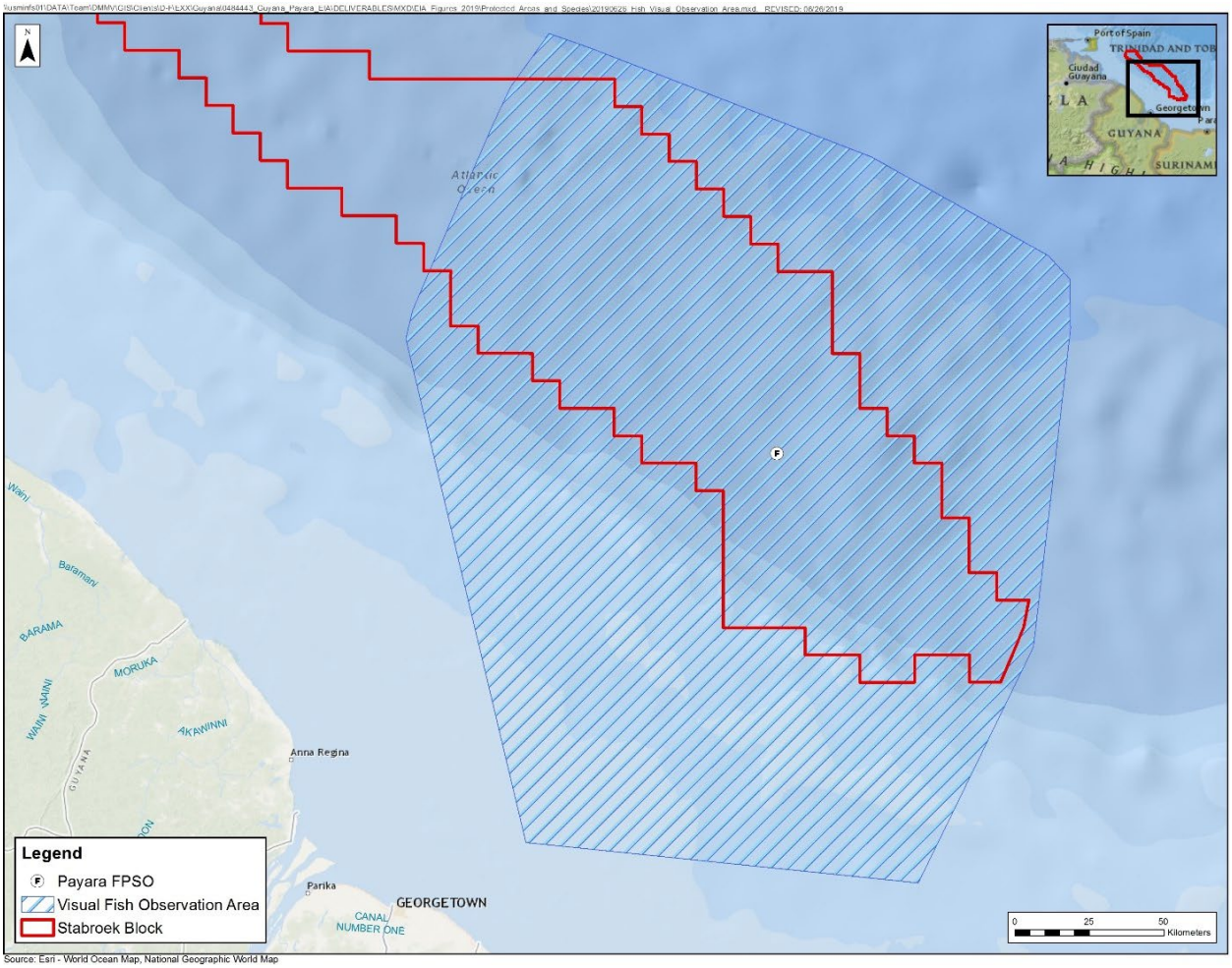


Figure 7.8-7: Approximate Area of Visual Fish Observations from EEPGL-Commissioned PSO Surveys since 2015

Table 7.8-2: Fish Species Observed in the Stabroek Block and between the Stabroek Block and the Guyana Shore during EEPGL-Commissioned PSO Activities Since 2015

Common Name	Scientific Name	IUCN Status [a]
Atlantic bonito	*Sarda sarda*	LC
Atlantic flying fish	*Chellopogon melanurus*	LC
Atlantic tripletail	*Lobotes surinamensis*	LC
bar jack	*Caranx ruber*	LC
blackfin tuna	*Thunnus atlanticus*	LC
blackwing flying fish	*Hirundichthys rondeletii*	LC
blue marlin	*Makaira nigricans*	VU
clearwing flying fish	*Cypselurus comatus*	LC
Eelpout	*Lycodonus* sp.	—
four-wing flying fish	*Hirundichthys affinis*	LC
jack crevalle	*Caranx hippos*	LC
king mackerel	*Scomberomorus cavalla*	LC

Common Name	Scientific Name	IUCN Status [a]
largehead hairtail	*Trichiurus lepturus*	LC
little tunny	*Euthynnus alletteratus*	LC
dolphinfish/mahi-mahi	*Coryphaena hippurus*	LC
manta ray	Mobula sp.	—
margined flying fish	*Cheilopogon cyanopterus*	LC
ocean sunfish	*Mola mola*	VU
planehead filefish	*Stephanolepis hispidus*	LC
Porcupinefish	*Diodon hystrix*	LC
rainbow runner	*Elagatis bipinnulata*	LC
sailfish	*Istiophrous albicans*	LC
skipjack tuna	*Katsuwonus pelamis*	LC
smalleye smoothhound	*Mustelus higmani*	LC
southern red snapper	*Lutjanus purpureus*	—
Swordfish	*Xiphiaa gladius*	LC
unidentified grenadiers	Macrouridae	—
unidentified skates and rays	Rajiformes	—
tiger shark	*Galeocerdo cuvier*	NT
tripodfish	Bathypterois sp.	DD-LC
yellowfin tuna	*Thunnus albacares*	NT

DD-LC = Data Deficient-Least Concern; LC = Least Concern; NT = Near Threatened; VU = Vulnerable
[a] IUCN status is given as "—" for multi-species groups or taxa for which a species-specific identification could not be made.

7.8.2.4. Nearshore Fish Community

The discussion of nearshore fish community data is derived from sampling conducted across all of the wet- and dry-season sampling dates identified above (i.e., September–October 2017, April 2018, January 2019, and May–June 2019). These nearshore surveys (Figure 7.8-8 and Figure 7.8-9) sampled coastal fish communities in Regions 1 through 5. The nearshore fish community was the second-most diverse marine zone sampled during the EEPGL-commissioned marine fish study (behind the continental shelf), accounting for 79 fish species.

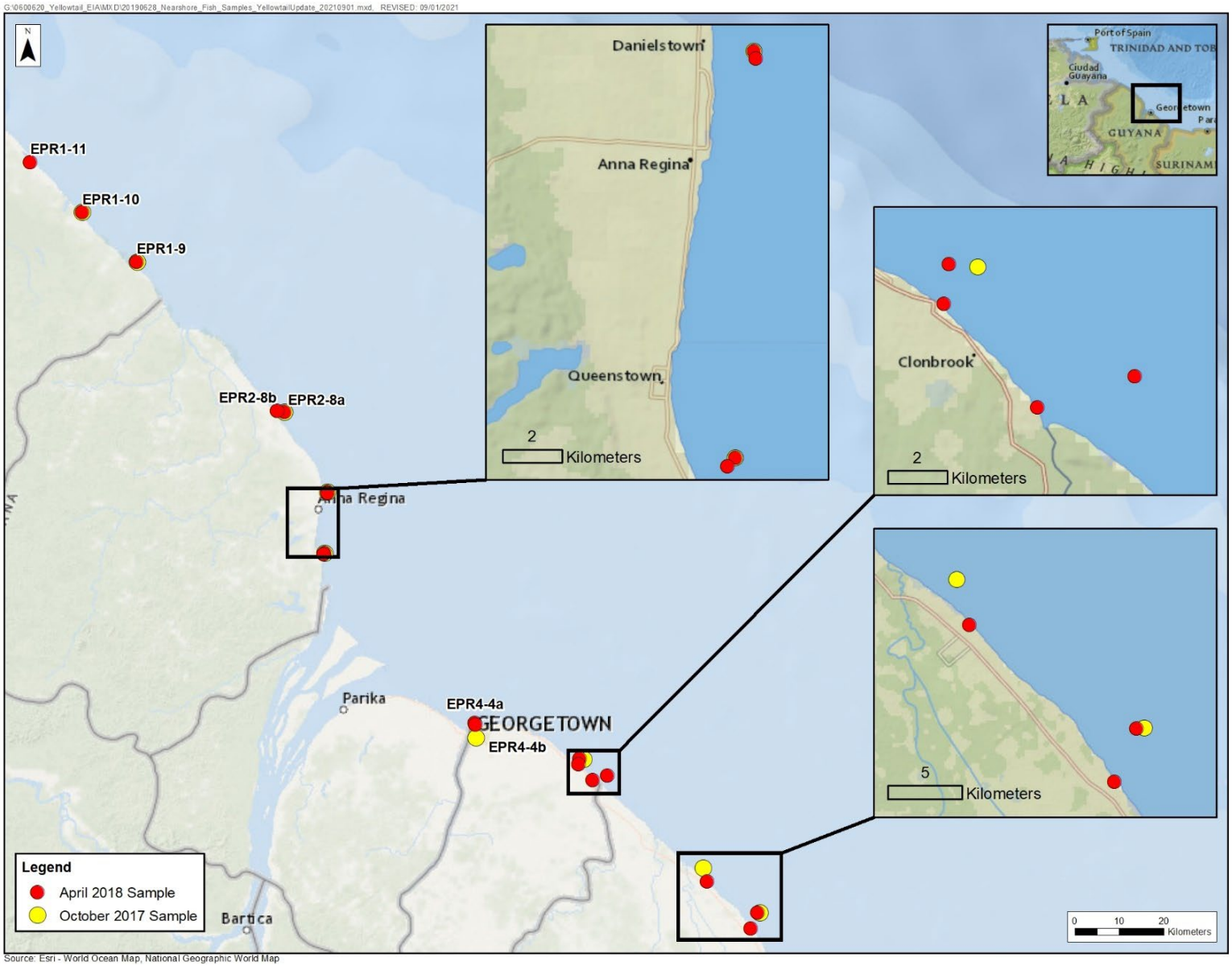


Figure 7.8-8: Nearshore Fish Sampling Stations during the First Year of EEPGL-Commissioned Study

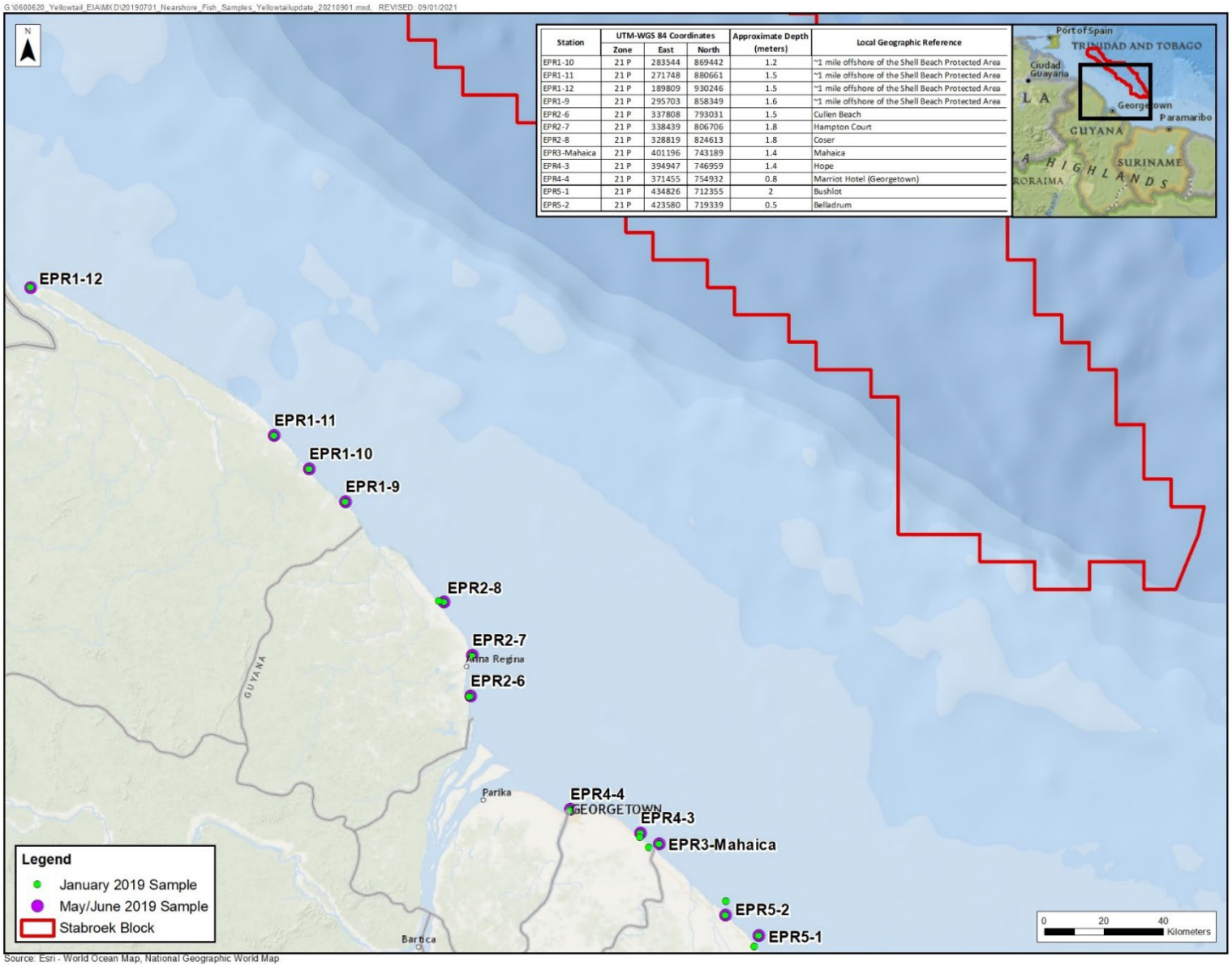


Figure 7.8-9: Nearshore Fish Sampling Stations during the Second Year of EEPGL-Commissioned Study

A total of 48 different species were captured during the nearshore fish assessment in the first year of the EEPGL-commissioned marine fish study. Twenty-five species were captured during the dry season, and the two most common species (bangamary and highwaterman catfish) were also common on the inner continental shelf during this period, underscoring the importance of marine influence during periods of low riverine discharge. The nearshore community shifts to a more freshwater/brackish community in the wet season; in fact, eight of the nine species captured in the 2018 wet season estuarine surveys also appeared in the wet season nearshore dataset. Most of the species captured in the nearshore zone during the wet season (April 2018) were anadromous or euryhaline species.

The wet season nearshore samples yielded 46 species. The January 2019 nearshore data included 29 species (54 percent of all species collected in that survey) that had not been collected at the nearshore stations in 2017 or 2018. Seven of these species were anchovies in the genera *Anchovia*, *Anchoviella*, *Lycengraulis*, and *Pseudenbatos*. Despite belonging to the same family (Engraulidae), sharing many superficial anatomical similarities, and occupying similar trophic positions in the foodweb, this group exhibits a wide range of habitat requirements and life histories. Some (e.g., Bates' sabretooth anchovy [*Lycengraulis batesii*]) have a predominantly freshwater distribution. Others (e.g., Zabaleta anchovy [*Anchovia clupeoides*]) have a predominantly coastal marine distribution, but are found in estuaries as well. Their simultaneous presence suggests that conditions in the nearshore zone in January 2019 were temporarily supportive of species from both the wet-season and dry-season communities at the limits of their respective ranges.

Sixty-two species were captured at the nearshore stations during the second study year. Thirty-four of these species were captured in both seasons. The most common species observed at the nearshore stations were white spring cariss (*Cathorops melanopus*), rockhead (*Stellifer microps*), highwaterman catfish, parassi mullet (*Mugil incilis*), and Pemecou sea catfish (*Sciades herzbergii*). Nearshore catches consisted primarily of catfish, which were found in salinities from 3.5 to 34 parts per thousand. The extreme variability in salinities at the nearshore stations is caused primarily by substantial freshwater inputs from rivers, which explains the dominance of estuarine species in all of the nearshore samples (including those located several kilometers away from river mouths) and the presence of freshwater species in some low salinity areas along the coast. Most of the species captured during the wet season were anadromous species that had presumably entered the coastal area from the sea in response to increased freshwater discharge to the coastal zone, or euryhaline species that entered the study area from farther up the rivers.

Similar to the continental shelf, seasonal influences on the nearshore fish community manifested differently in the first and second years of the EEPGL-commissioned marine fish study. During the first study year, total diversity in the nearshore zone was comparatively low and there was a marked difference in the total number of species captured between seasons. In the second year, the total number of species captured across both seasons was higher. About 45 percent of the species were found in only one season, but the total number of species captured was identical for both seasons. Region 2 had the most diverse fish community in both

years and in both seasons in the second study year, which illustrates the importance of the Essequibo River's freshwater inputs in shaping the nearshore fish community. Although freshwater inputs clearly influence fish distribution, proximity to rivers is not the only factor that influences nearshore fish diversity. A few nearshore stations located in close proximity to river mouths had lower than average species diversity. This phenomenon was exemplified at EPR2-6. No fish were captured at this station during the wet season in the second study year, when freshwater influence was presumably near its annual peak. It is possible that a moderate amount of freshwater increases fish diversity, but that above a certain threshold, diversity begins to decrease as large numbers of marine species are excluded; the exact nature of the relationship between salinity and nearshore fish diversity in Guyana is currently unclear.

7.8.2.5. Estuarine Fish Community

The discussion of estuarine fish community data is derived from sampling conducted across all of the wet- and dry-season sampling dates identified above (i.e., September–October 2017, April 2018, January 2019, and May–June 2019). These estuarine surveys (Figure 7.8-10 and Figure 7.8-11) sampled coastal fish communities in Regions 1 through 5. Eight species were captured at the estuarine/riverine stations in the first year of the EEPGL-commissioned study. Catches were dominated by white basha (*Plagioscion* sp.) and white puffer (*Colomesus psitacus*). Twenty-one species were captured at the estuarine/riverine stations during the second study year. Parassi mullet (*Mugil incilis*), rockhead, Zabaleta anchovy (*Anchovia clupeoides*), and false herring (*Harengula clupeola*) were the most common species collected at the estuarine/riverine stations during the second study year. The stations with the highest catches of juvenile fish in both years were located near riparian vegetation such as aquatic plants, grass, submerged palm trees, and plants of small size with abundant foliage. Smaller catches were associated with areas among mangrove roots. The abundance of Leptocephali (a larval form that is unique to elopomorphic fish, primarily the marine and diadromous eels) in the estuarine samples points to the value of the estuaries as nursery areas. A noteworthy aspect of the estuarine surveys was the prevalence of leptocephalus[32] larvae in the first-year samples. The larvae were not identified to species, but they comprised more than 30 percent of the entire catch across the five estuarine stations and were the most common species in the wet season (April) estuarine dataset in 2018. Tarpon and ladyfish are both nearshore marine/estuarine species, but the leptocephali could also have been the larvae of a marine eel, such as a moray. Regardless of the species, their ubiquity and abundance in the estuarine stations underscores the importance of the estuaries as fish nursery habitats.

[32] A leptocephalus is a slim, transparent larval form of eels and other more distantly related species including tarpon (*Megalops atlanticus*), known as "cuffum" in Guyana, and ladyfish (*Elops saurus*), known as "silverfish" in Guyana.

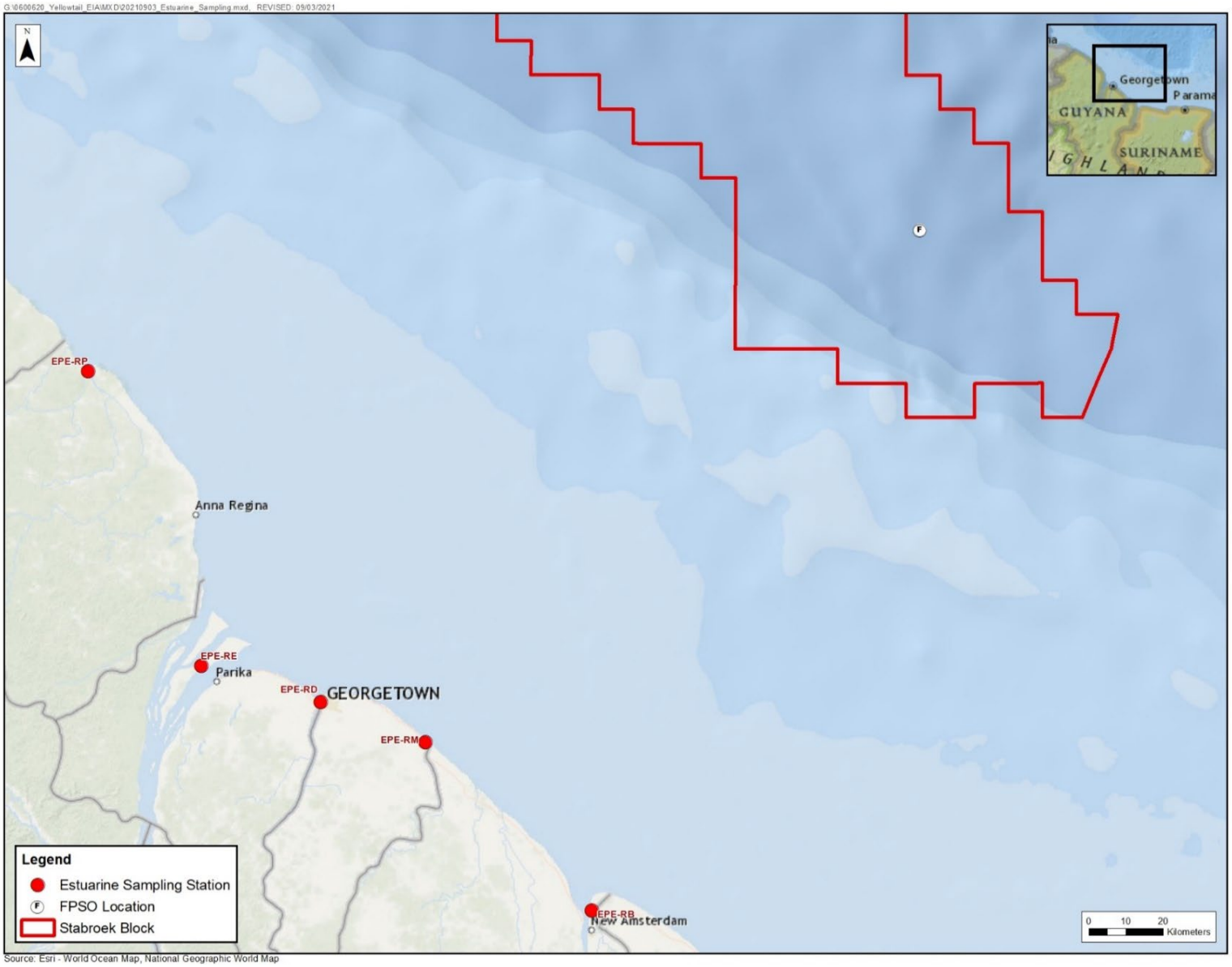


Figure 7.8-10: Estuarine Fish Sampling Stations during the First Year of EEPGL-Commissioned Study

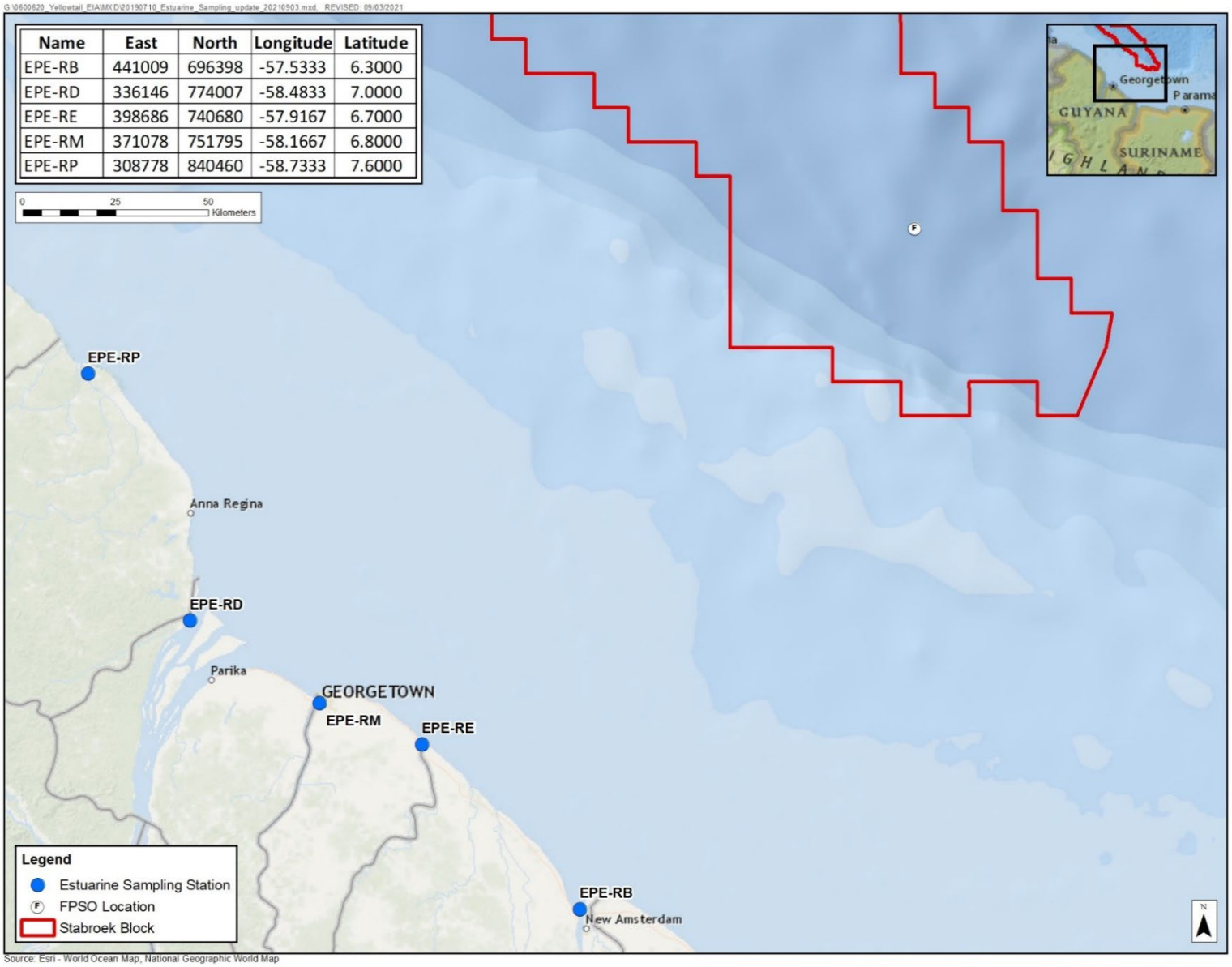


Figure 7.8-11: Estuarine Fish Sampling Stations during the Second Year of EEPGL-Commissioned Study

7.8.2.1. Ichthyoplankton Community

The ichthyoplankton community was sampled across 17 stations distributed across all four zones (deepwater, continental shelf, nearshore, and estuarine) in December 2018–January 2019 and May–June 2019 (Figure 7.8-12).

Forty-seven species of fish in 29 families were identified in the ichthyoplankton samples taken from the deepwater zone. Most of the ichthyoplankton collected from the deepwater zone were eggs, with comparatively small numbers of post–yolk sac larvae. No yolk sac larvae were collected. The most common and most diverse family was Scombridae (mackerels and tunas), with 37 percent of the entire number of individual planktonic fishes collected and eight species (approximately 20 percent of the species collected). The second- and third-most abundant families were the Dactylopteridae (round herrings) and Nomeidae (snappers). The second- and third-most diverse families were Myctophidae (lanternfish, five species) and, with three species each, the Carangidae (jacks), Serranidae (seabasses and groupers), and Sphyraenidae (barracudas). All ichthyoplankton in the deepwater zone were captured in the dry season; the deepwater zone was sampled in the wet season; no plankton were recovered from the wet season samples.

Seventy-two fish species in 36 families were identified from the plankton samples taken from the continental shelf zone. Small numbers of sailfin flyingfish (*Parexocoetus brachypterus*) eggs were collected in the wet season; all other species were captured in the dry season only. No eggs were collected in the dry season. Most ichthyoplankton captured on the continental shelf in the dry season were post–yolk sac larvae with small numbers of yolk sac larvae and leptocephalus larvae mixed in. The most abundant family was Sciaenidae, followed by Carangidae and Scombridae, which together accounted for slightly more than 50 percent of the entire number of individual planktonic fishes collected. The most diverse ichthyoplankton families on the continental shelf were Scombridae (10 species), Myctophidae (eight species), and Sciaenidae (six species). Together, these species accounted for 33 percent of the species collected.

Twenty-two species of fish in 11 families were identified from the plankton samples from the nearshore zone. No eggs were collected in the nearshore zone; most of the ichthyoplankton captured in the nearshore zone were post–yolk sac larvae with small numbers of yolk sac larvae and early juveniles mixed in. The most abundant family was Engraulidae (anchovies), followed by Sciaenidae and Gobiidae (gobies), which together accounted for 97 percent of the entire number of individual planktonic fishes collected. The dominance of these three families was primarily due to the overwhelming abundance of two species in particular, broadband anchovy (*Anchoviella lepidentstole*) and acoupa weakfish (*Cynoscion acoupa*), which together accounted for more than 76 percent of all ichthyoplankton collected in the zone. The most diverse ichthyoplankton families in the nearshore zone were Sciaenidae and Engraulidae. Together, these two families accounted for 50 percent of the species collected. All ichthyoplankton in the nearshore zone were captured in the dry season; none were captured in the wet season.

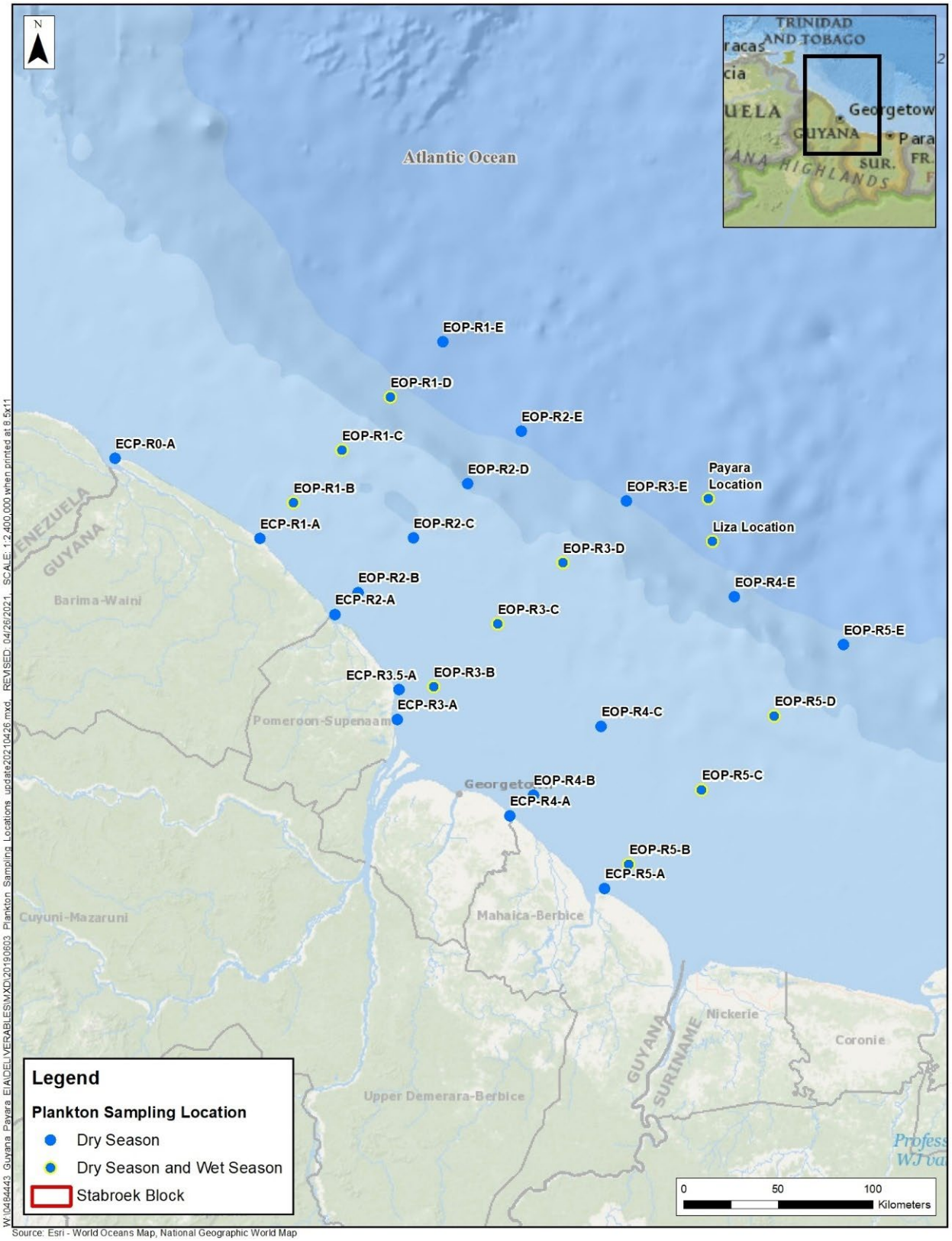


Figure 7.8-12: Ichthyoplankton Sampling Locations

The total diversity of the ichthyoplankton community across the study area was remarkable. One hundred and eleven species of fish were represented in the plankton samples, accounting for 55 percent of the total number of species represented from both years of the EEPGL-commissioned marine fish study. An additional 78 taxa were identified to a higher taxonomic rank, producing a total of 189 total taxa identified in the ichthyoplankton study. The paucity of ichthyoplankton in the wet season samples was unexpected, but not inconsistent with local traditional knowledge. As documented in Appendix D, Participatory Fishing Study Final Report January 2019–March 2020[33], local fisherfolk generally believe that spawning activity for most marine fish peaks from July through September, which is just after the wet season plankton samples were collected. It is not known whether the comparatively high number of ichthyoplankton collected during the dry season is typical of this season, or if a late spawn in 2018 increased the numbers of plankton beyond the normal seasonal levels for this period. Although the degree of seasonal difference in ichthyoplankton concentrations was unexpected, the differences in species composition between the zones was expected and consistent with known habitat preferences for the various families of fishes represented in the samples.

Summary of Available Marine Fish Data for the Guyana EEZ

The EEPGL-commissioned marine fish surveys and incidental fish data collected during other offshore activities identified several intra-annual and spatial trends:

1. The continental shelf, particularly the mid- to outer-shelf, has higher marine fish diversity than other areas of the EEZ (i.e., deepwater and nearshore/estuarine areas). This is likely due to a combination of factors, including the shelf's relatively large size, wide range of physiochemical conditions present, and high rates of primary productivity compared to nearshore and deepwater/offshore zones.
2. Spatial trends in fish diversity on the continental shelf correlate well with spatial trends in water quality. The middle to outer continental shelf is an area of transition from the mixture of "blackwater"[34] and highly turbid silt-laden water near shore to clearer waters more characteristic of offshore conditions. This observation is supported by turbidity data collected from the continental shelf stations, and aligns with the species composition of the fish community in this zone, which includes species with a mix of water quality and salinity preferences.
3. Fish abundance fluctuates in the nearshore and inner continental shelf regions in response to seasonal influx of freshwater from rivers. This is likely due to changes in temperature and other water quality parameters, particularly on the inner continental shelf where the effects

[33] At the time this EIA was prepared, the Participatory Fishing Study was an ongoing study. The Final Report January 2019–March 2020 was the final report for the first year of this study only.
[34]The clarity of water flowing out of Guyana's rivers onto the continental shelf is limited by two types of influences. The first is so-called "blackwater" contributions, which come from swamps and other wetlands that characteristically have deep accumulations of organic debris. Water flowing from these areas has a very dark color and low light transmissivity because of high tannin content, but typically has very low suspended solids. The second type of influence has very high suspended solids content (i.e.; turbidity) but little if any tannin content. In the estuaries and near-shore marine environments where both of these types of water mix with oceanic water, water clarity is typically low.

of freshwater influx during the rainy season are strongest. This is reflected in the fishing sector's tendency to call the periods from May–September and October–April as the "good" and "hard" seasons, respectively.

4. Ichthyoplankton densities appear to be strongly influenced by season. Although conclusions with respect to ichthyoplankton must be considered very preliminary because they are based on data from a single survey year (i.e., one wet season and one dry season), this finding is consistent with local traditional knowledge, which indicates that spawning activity for most marine fish peaks from July through September.

The Participatory Fish Survey (Appendix D, Participatory Fishing Study Final Report January 2019–March 2020) also identified some trends to date, including seasonal increases in fishing effort from October to April, the increasing effect that fuel prices are having on fishing practices, a recent increase in the demand for (and effort directed to) swim bladders, and the increasing effect of sargassum incursions on catches. These findings are discussed further in Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources.

7.8.3. Impact Assessment—Marine Fish

This section addresses the potential impacts of planned Project activities on marine fish. Key potential impacts on marine fish assessed include changes in the distribution of fish due to altered water quality; auditory impacts on fish from vessel activity, VSP activities, and pile driving; localized changes in distribution and habitat usage due to altered bottom habitats and the presence of Project infrastructure; attraction to artificial light; and entrainment in water intakes.

Although marine fish are grouped as a single receptor in this EIA, the term "marine fish" encompasses several groups including pelagic species, demersal species, resident species, and migratory species. Each of these groups will have a unique set of sensitivities and exposures to different Project-related impacts depending on their differing habitat requirements and life histories. For example, surface-dwelling pelagic fish (e.g., flyingfishes, mackerels) will have a greater potential to experience water quality changes related to planned discharges compared to bottom-dwelling species, and bottom-dwelling species (e.g., snappers) will have a greater potential to experience changes in physical habitat structures compared to pelagic species.

7.8.3.1. Relevant Project Activities and Potential Impacts

Table 7.8-3 summarizes the planned Project activities that could potentially impact marine fish.

Table 7.8-3: Summary of Relevant Project Activities and Key Potential Impacts—Marine Fish

Stage	Project Activities	Key Potential Impact
Development Well Drilling SURF/FPSO Installation, Commissioning, and Start-up	Drilling operations and VSP	• Changes in the distribution of fish due to altered water quality • Auditory impacts from vessel sound • Auditory impacts from sound from VSP and pile driving • Attraction to artificial light
	Artificial lighting on drill ships and major installation vessels	
	Installation of FPSO moorings and SURF equipment, including pile driving	
	Permitted effluent discharge	
	Permitted drill cuttings and fluids discharge	
Production Operations	Permitted effluent discharge (primarily cooling water and chlorinated effluent)	• Changes in the distribution of fish due to altered water quality • Auditory impacts from vessel sound • Changes in distribution and habitat usage due to altered bottom habitats and the presence of Project infrastructure • Loss of fish eggs and larvae due to entrainment of immature life stages • Attraction to artificial light
	Tanker and tug operations	
	Presence of subsea infrastructure	
	Intake of seawater for cooling water, injection water, and ballast water	
	Artificial lighting on the FPSO	
Decommissioning	Abandonment and removal activities	• Auditory impacts from vessel sound • Changes in the distribution of fish due to altered water quality • Attraction to artificial light
	Permitted effluent discharge	

On the basis of the definitions and embedded controls described in Table 7.8-11, the characteristics of the various potential impacts on marine fish identified in Table 7.8-3 are discussed below.

7.8.3.2. Magnitude and Sensitivity Definitions for Potential Impacts on Marine Fish

Following the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude ratings of potential impacts on marine fish are determined based on geographic extent, frequency, duration, and intensity (see Table 7.8-4).

Table 7.8-4: Definitions for Intensity Ratings for Potential Impacts on Marine Fish

Criterion	Definition
Intensity	Negligible: No Project-related disturbance or injury of marine fish, or disturbance across only a very limited area.
	Low: Limited Project-related disturbance or injury of marine fish is perceptible, potentially causing slight changes in the behavior of marine fish.
	Medium: Project-related disturbance or injury of marine fish is evident, potentially leading to minor impacts on life functions (e.g., feeding, breeding, migration route changes).
	High: Project-related disturbance or injury of large numbers of marine fish, sufficient to cause extensive mortality or chronic behavioral changes at a population level.

Several marine fish species with an elevated IUCN conservation status are known to occur in the PDA based on direct capture or visual observation, but the bulk of the marine fish observed or captured do not have an elevated IUCN status. Table 7.8-5 provides definitions for receptor sensitivity ratings for potential impacts on marine fish. These definitions apply for only those species rated as Least Concern, Data Deficient, or not assessed on the IUCN Red List. Species rated as Near Threatened or higher are addressed in Section 7.1, Protected Areas and Special Status Species. Based on the sensitivity rating definitions below, the receptor sensitivity for marine fish is generally considered **Low** for pelagic species and **Medium** for demersal species. This is principally due to the fact that demersal species are less mobile than pelagic species and would therefore be more susceptible to localized Project impacts; however, this difference in relative sensitivity does not apply for demersal species that are highly mobile or have demonstrated habituation to a particular impact.

Table 7.8-5: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Marine Fish

Criterion	Definition
Sensitivity	Low: Species and sub-species without specific anatomical, behavioral, or ecological susceptibilities to Project-related impacts, or having previously demonstrated habituation to a specific category of anticipated impact.
	Medium: Species with one of the following characteristics: specific anatomical, behavioral, or ecological susceptibilities to Project-related impacts; importance to local or regional fisheries; or vital importance to the survival of another medium-sensitivity species, but not meeting criteria for high value sensitivity.
	High: Species with two of more of the following characteristics: specific anatomical, behavioral, or ecological susceptibilities to Project-related impacts; importance to local or regional fisheries; or vital importance to the survival of another medium-sensitivity species.

7.8.3.3. Characterization of Impacts—Changes in the Distribution of Fish Due to Altered Water Quality

The Project will routinely discharge several effluent streams to the sea. These discharges will begin during the drilling and installation stages and continue into the decommissioning stage. Drilling fluids and cuttings discharges will be unique to the drilling stage. The initial well sections will use WBDF, and the cuttings and fluids will be discharged either at the seafloor—causing turbidity near the seafloor around the immediate vicinity of each well, or from the drill ships—causing turbidity higher in the upper water column. For subsequent well sections, cuttings and

residual drilling fluids will be discharged from the drill ships. For discharges from the drill ships, turbidity plumes will impact a larger area as the cuttings fall through the water column; however, the turbidity plume in this case will be diluted across a larger area, thereby reducing potential related impacts at any single location. Fish are expected to generally avoid these turbidity plumes while drilling is occurring, reducing potential respiratory impacts associated with gill fouling, but are expected to return after drilling is complete. WBDF and the residual quantities of low-toxicity NABF adhered to discharged cuttings are expected to have no measurable toxicological impacts on fish.

As described in Section 6.4.3, Impact Assessment—Marine Water Quality, and Appendix C, Water Quality Modeling Report, most of the planned discharges that will occur during production operations are not known to have adverse impacts on marine life or will comprise negligible volumes; however, the increased temperature and chlorine concentrations in the cooling water discharges have the potential to adversely impact marine life. Elevated temperature is known to have several potential physiological lethal and sub-lethal impacts on fish, including reduced reproductive success, reduced early life-stage survivorship, and increased metabolic stress. Thermal thresholds for such impacts vary widely by species, but thresholds from the scientific literature range from about +1.5°C (2.7°F) to +6°C (10.8°F; Donelson et al. 2014; Pankhurst and Munday 2011). Under the conservative assumptions described in Section 6.4.3, Impact Assessment—Marine Water Quality, localized sea surface temperatures around the point of discharge from the FPSO are expected to increase as a result of the Project, but these increases are predicted to be no more than 3°C (5.4°F) above ambient temperatures within 100 meters (approximately 330 feet) horizontal distance from the discharge outlet. This finding indicates that within 100 meters (approximately 330 feet) of the FPSO, the intensity of thermal discharges will diminish to near the lower end of the range within which adverse thermal impacts on fish are expected to occur. It is also noted that most of the research on thermal thresholds for these types of impacts has focused on reef- or structure-oriented species that spend their entire adult lives in a small area rather than the open-ocean pelagic species that will occur near the surface in the PDA. Pelagic species will be much more likely to move away from a thermal mixing zone that exceeds their optimum range than will structure-oriented species, so not only will thermal impacts affect a very small area of the ocean surface, but the species that occur within the PDA will also tend to be exposed less to these thermal impacts based on their propensity to actively avoid suboptimal water temperatures.

Similar to temperature increases, hypochlorite can also induce a range of negative impacts on fish, including disruption of cardiac function, respiration, and growth (European Communities 2007). There are no regulatory limits for residual hypochlorite in marine discharges in Guyana, and toxicity depends not only on dosage (concentration and exposure time) but also on individual species' sensitivity to hypochlorite. This makes defining a single impact threshold for hypochlorite exposure difficult. Most studies indicate harmful effects on fish have been observed at mean concentrations above 0.2 parts per million (ppm) (Kegley et al. 2016). Although the available studies cite a variety of exposure times and toxicity endpoints, they generally indicate residual chlorine from hypochlorite poses the greatest risk to aquatic species if they are exposed to elevated concentrations for extended periods of time (72 to 96 hours) (see Appendix

C, Water Quality Modeling Report). While hypochlorite concentrations immediately adjacent to the discharge point could transiently exceed levels that pose fish toxicity concerns (assuming the fish remained in the area long enough to experience the impact), concentrations are expected to decrease to less than 0.11 ppm within 100 meters (approximately 330 feet) of the discharge point.

The combined impact of increased temperature and chlorine concentrations will make the localized mixing zone inhospitable to some species. However, unless fish are physically confined or otherwise prevented from escaping unfavorable water quality conditions (e.g., in the case of fish eggs), fish are usually capable of detecting and avoiding harmful water quality conditions, thereby minimizing potential toxicological impacts (Svobodová et al. 1993). This is especially true of water quality conditions that cause discomfort or are otherwise physically apparent at sub-lethal levels like hypochlorite. The vast majority of the fish species that occur in the mixing zone are highly migratory open-ocean species, and as such would be expected to briefly pass through the mixing zone rather than loiter within it. Fish that pass through the 100-meter (328-foot) mixing zone surrounding the FPSO would be temporarily exposed to elevated concentrations of various constituents in the routine FPSO discharges. The effects of these constituents on these fish could manifest in several ways, such as elevated metabolic rates and/or gill or skin irritation, but these effects would generally be expected to be temporary and to abate once the fish exited the mixing zone. To the extent that increased forage availability could induce large predatory fish to remain within the mixing zone longer than they otherwise would (similar to seabirds and marine mammals as discussed in Sections 7.4.3, Impact Assessment—Seabirds, and 7.5.3, Impact Assessment—Marine Mammals, respectively), the negative effects of increased exposure to discharges would be balanced by the energetic benefits of increased forage availability.

Installation of moorings for the FPSO, installation of SURF equipment, and drilling of development wells will disturb the seafloor temporarily within the PDA. These disturbances will create turbidity plumes and alter localized bottom contours within the area. The main potential impacts of turbidity plumes on fish are gill fouling and reduced visibility (Andree and Wahl 2019). Visibility is a minor factor at the depths that occur in the PDA because the species that live at these depths are naturally adapted to what is essentially total darkness, but fouled gills can lead to respiratory distress over long exposures. The turbidity plumes are expected to dissipate rapidly downcurrent, and fish are expected to temporarily vacate the immediate vicinity of activities at the seafloor until turbidity reaches acceptable levels. This behavioral response will limit fishes' exposure to turbidity, and fish are expected to return to the vicinity of the Project subsea infrastructure once seafloor disturbance activities are complete. Decommissioning will cause similar small turbidity plumes near the seafloor if selected components of the SURF are removed and as mooring lines from the FPSO are placed on the seafloor. Impacts from these turbidity plumes will be similar to those associated with drilling and installation, although they will be smaller and have a shorter duration.

For these reasons, declines in water quality are expected to negatively impact fish abundance in the immediate vicinity of the well heads, SURF, and drill ships during drilling and installation, the FPSO and tanker(s) during production operations, and the SURF during decommissioning, but

are not expected to cause significant fish mortality. Limited, localized impairments in water quality will be largely confined to the PDA, but they will likely cause minor changes in the distribution and composition of the fish community within parts of the PDA. As discussed below, the physical attraction that offshore facilities can exert on fish could actually result in net increases in the local abundance of certain fish species, thereby offsetting potential negative impacts associated with localized water quality impairment. The net impact in this case is predicted to be a localized shift away from sensitive species (including some pelagic and sedentary species) toward sedentary or structure-oriented species that are more tolerant of minor water quality impairments. Any impacts on transient fish swimming through the mixing zone are expected to be acute, and affected individuals are expected to recover quickly after exiting the mixing zone.

In summary, offshore pelagic fish will be exposed to:

- Permitted liquid effluent discharges and elevated total suspended solids (TSS) concentrations resulting from discharge of drill cuttings from drilling of bottom-hole sections during the drilling and installation stage;
- Permitted liquid effluent discharges as a result of FPSO discharges during the production operations stage; and
- Permitted liquid effluent discharges from decommissioning vessels during the decommissioning stage.

Offshore demersal species will be exposed to:

- Elevated TSS concentrations at the seafloor resulting from drilling the initial (riserless) well sections during the drilling and installation stage; and
- Elevated TSS concentrations during decommissioning stage seabed disturbance.

The potential for bioaccumulation was considered but ultimately not assessed in the EIA because bioaccumulation is typically a long-term impact that occurs over time due to ongoing chronic exposure to a pollutant. Most of the fish species that occur in the mixing zone of operational effluent discharges would be expected to briefly pass through the mixing zone rather than remaining within it for any significant period of time. Due to the very limited exposure that pelagic species will have to the mixing zone, potential impacts on marine fish from bioaccumulation of pollutants in Project effluents were not rated.

The intensity of impacts on pelagic and demersal offshore species is considered **Low** for drilling and installation stages because while drill cuttings discharges will result in TSS concentrations above biological thresholds, the portion of the Stabroek Block that will be exposed to concentrations that exceed biologically relevant water quality standards is relatively small; accordingly while fish may change their movement patterns slightly to avoid impaired water quality, these behavioral changes will be slight.

The intensity of impact on pelagic species will remain **Low** during production operations due to FPSO discharges, but the intensity of impact on demersal species will decrease to **Negligible** during production operations, because water quality impacts at the seafloor will cease during

normal operations. During the decommissioning stage, the intensity of impact on pelagic species will be **Negligible** due to the elimination of FPSO discharges; while demersal species will experience an impact from seabed disturbance during decommissioning, the area in which this impact will occur will be very localized in nature, yielding a **Negligible** intensity. Coastal species will not be exposed to discharges from planned Project activities. Discharges from drilling and installation vessels, the FPSO, and decommissioning vessels will occur on an essentially continuous basis in the PDA during their respective stages of activity, so the frequency of this impact is considered **Continuous** for all Project stages. Elevated TSS concentrations from drill cuttings discharges and from seabed disturbance during decommissioning will persist for less than a year in aggregate, so the duration of water quality impacts for these stages is considered **Medium-term**. Discharges from the FPSO will occur over the entire life of the Project (i.e., on the order of at least 20 years), so the duration of the impact for this stage is considered **Long-term**. This yields magnitude rating ranging between **Negligible** and **Small** for potential impacts on marine fish (Table 7.8-6).

Table 7.8-6: Magnitude Ratings for Potential Impacts on Marine Fish from Altered Water Quality

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Drilling and Installation	Exposure to Altered Water Quality (Offshore Pelagic and Offshore Demersal Species)	Direct AOI	Low	Continuous	Medium-term	Small
Production Operations	Exposure to Altered Water Quality (Offshore Pelagic Species)	Direct AOI	Low	Continuous	Long-term	Small
	Exposure to Altered Water Quality (Offshore Demersal Species)	Direct AOI	Negligible	Continuous	Long-term	Negligible
Decommissioning	Exposure to Altered Water Quality (Offshore Pelagic and Offshore Demersal Species)	Direct AOI	Negligible	Continuous	Medium-term	Negligible

Impact Significance—Exposure to Altered Water Quality

Based on the magnitude of impact and receptor sensitivity ratings described above, the premitigation significance rating for potential water quality-related effects on marine fish ranges from **Negligible** to **Minor**.

7.8.3.4. Characterization of Impacts—Auditory Impacts on Marine Fish from Vessel Activity, Vertical Seismic Profile Activities, and Pile Driving

The same sound sources associated with the Project that could impact marine mammals (Section 7.5.3, Impact Assessment—Marine Mammals) could also impact marine fish. These can be broadly separated into non-impulsive sources (e.g., vessel sound) and impulsive sources (pile driving and VSP). Hearing abilities and sensitivities differ significantly among fish species. Certain species can be classified as hearing generalists or specialists[35] based on differences in hearing ability conveyed by specific anatomical traits. Although hearing specialists are thought to be more susceptible to auditory impacts within certain audio frequencies than other species, there are no generally accepted thresholds for auditory impacts in either specialist or generalist species, and many species' hearing abilities have yet to be quantified.

Non-Impulsive Sound

A 2014 Environmental Impact Statement conducted by the U.S. Department of the Interior as part of a Programmatic Environmental Impact Statement for proposed geological and geophysical investigations in the Atlantic Outer Continental Shelf off the southeastern United States (BOEM 2014) contained a comprehensive review of auditory impacts on fish from non-impulsive and impulsive sources (including seismic surveys). This study found that fish may experience a range of impacts from non-impulsive sound, including increased stress and threshold shift, and fish may employ behavioral strategies to avoid the sound source (BOEM 2014).

Pelagic marine species and nearshore demersal species will receive the highest exposure to nonimpulsive sound because they will be closest to the sound source (i.e., the FPSO and marine vessels associated with the Project). The extent to which auditory impacts will actually occur is highly dependent on the hearing abilities and sensitivities of the species of these fish species and these abilities and sensitivities are currently unknown, but pelagic species have an almost limitless ability to avoid approaching vessels. As discussed in Section 7.8.2.4, Nearshore Fish Community, the nearshore fish community (including those in the approaches to the Demerara River) is dominated by highly mobile species as well (see Section 7.8.2.4); accordingly, the intensity of potential auditory impacts on pelagic marine species and nearshore demersal species from vessel activity (during all Project stages) is considered **Negligible**. Due to the depths present offshore and the resulting distance between the seafloor and vessels at the surface, the intensity of impacts on offshore (continental shelf and deepwater) demersal species from non-impulsive sound (during all Project stages) is also considered **Negligible**. These sounds will be present whenever the FPSO or support vessels are operating in the PDA or when support vessels are passing through the transit corridor between the PDA and shorebases. The FPSO will be a continuous source of sound, so the frequency of impact for pelagic and offshore demersal species during production operations is considered **Continuous**.

[35] Hearing specialists are species that have developed heightened sensitivities to sounds in a specific frequency range. This adaptation occurs in some species to facilitate feeding or social behavior. Hearing generalists hear equally well across a wider range of frequencies but do not possess the acuity of the specialists within their specific frequency range.

Based on the limited number of support vessel movements associated with the Project (on the order of an average of four one-way movements per day during drilling, installation, and decommissioning; and three one-way movements per day during production operations), the frequency of impacts from non-impulsive sound during the drilling and installation stage is considered **Episodic** for all species, and the frequency of impacts from nonimpulsive- sound during the production operations stage is considered **Episodic** for nearshore demersal species. Although the proportion of total vessel sound contributed by each type of vessel will vary over time, sound emanating from drill ships, installation vessels, the FPSO, support vessels, offloading tankers, and tugs decommissioning vessels will occur over the entire span of the Project, so the duration of impact from non-impulsive sound is considered **Long-term**.

Impulsive Sound

The impact of impulsive sounds on hearing specialists is the most important factor to consider when assessing potential Project-related auditory impacts on fish for the following reasons:

- Impulsive sound is usually considered more important than non-impulsive sound in terms of impacts on fish because impulsive sound is the category most often associated with hearing loss, auditory injury, or auditory mortality of fish.
- Impulsive sources tend to have more severe impacts on hearing specialist species and those species with well-developed swim bladders[36] because they tend to be more sensitive to auditory impacts, especially within the range of frequencies that they are specially adapted to detect.
- High peak pressures and rapid onset and decay tend to be associated with the most severe auditory impacts on fish, and are characteristic of impulsive sources.
- As described in Appendix H, Underwater Sound Modeling Report, impulsive sound from driven piles and VSP will impact a larger area of the ocean than the non-impulsive sources modeled by JASCO and therefore could impact a larger number of species and individual fish than could the non-impulsive sources.

There have been no published reports to date documenting a lasting impact on fishing or fish stocks as a result of seismic surveys. The U.S. Bureau of Ocean Energy Management (BOEM 2014) concluded that although hearing specialists are more susceptible than hearing generalists to hearing loss from impulsive sound, such impacts do not always occur and are generally not permanent. Wardle et al. (2001) observed initial “startle” reactions when reef-dwelling fish were exposed to impulses from a seismic array ranging from 210 dB to 195 dB re 1 µPa, but documented no long-term effects on fish behaviors or movements at or around the reef. Slotte et al. (2004) used echosounders to assess large-scale movements of uncaged fish in response to seismic impulses and found that fish may vacate an area in response to seismic survey activity, but that such avoidance behaviors are short-term and that fish begin to return to more normal distributions within a few days after exposure. Most recently, a study offshore

[36] Caged exposure tests have determined that species with large swim bladders or other highly vascularized, low-density organs or structures tend to be more susceptible to acute acoustic injury than species that lack these features when exposed to such sources within a few meters (Amoser and Ladich 2005; Wysocki and Ladich 2005).

northwest Australia found no evidence that seismic surveys affect the composition, abundance, size structure, behavior, or movement of marine fishes (Meekan et al. 2021).

Impacts are expected to be most severe in resident fish that are oriented to structural bottom habitats and are therefore exposed to repeated impulses at a given location over time, but experiments have shown that impacts on these species are often undetectable or transitory. Grebe et al. (2009) exposed a variety of demersal and reef-associated species to seismic impulses and failed to document auditory injury in any species at cumulative SEL levels up to 190 dB re 1 μPa^2-s. Another study of the reef-oriented pollack (*Pollachius pollachius*) documented only minor changes in behavior when exposed to seismic impulses with peak sound pressures of 195 to 218 dB re 1 µPa at ranges of 5.3 to 109 meters (17.4 to 357.6 feet) (Wardle et al. 2001). Documented recovery times vary, but generally range from a few hours to a few days.

The available literature described above suggests that behavioral impacts from impulsive sound sources may begin to occur at peak sound pressures between 180 and 195 dB re 1 µPa, and that injury could occur at peak sound pressures around 220 dB re 1 µPa. The acoustic modeling conducted to assess impacts on marine mammals provides insights into the approximate area of ocean within which behavioral impacts on fish could occur (Appendix H, Underwater Sound Modeling Report). JASCO simulated propagation of impulsive sound from pile driving at a range of dB levels that correspond to the lower to middle range in which behavioral impacts begin to be observed in fish. At low frequencies, where most hearing specialist species tend to be most sensitive, sound levels of 198 dB re 1 µPa were predicted at 1,375 meters (4,511.2 feet) from the sound source. This threshold is near the middle of the range in which behavioral impacts begin to be observed in fish and represents the “worst” case (i.e., largest area of impact) that JASCO modeled. Higher frequency sound attenuated below the 198 dB re 1 µPa threshold at a much shorter distance from the source (i.e., 725 meters [2,378.6 feet]). Although fish-specific noise acoustic modeling was not conducted for this impact assessment, extrapolation from JASCO’s analysis strongly suggests that behavioral impacts on fish from impulsive sound will be confined to less than 1.5 kilometers (0.9 mile) from the source.

The intensity of potential auditory impacts on pelagic species from pile driving (during FPSO and SURF installation) is considered **Negligible** due to the depth of acoustic source relative to the surface waters where pelagic species are usually found. The intensity of impacts on demersal species from pile driving (during FPSO and SURF installation) and VSP (during development well drilling) is considered **Medium** based on consideration of the predicted sound levels from these activities, the distance to which they would be expected to propagate, and the proximity of these species to the source. Coastal species will not be exposed to impulsive sound from the Project. Impulsive sounds will occur on an intermittent basis over a relatively short period of time, so the frequency and duration are considered **Episodic** and **Short-term**, respectively.

This yields a magnitude rating of **Negligible** for potential auditory impacts from non-impulsive and impulsive sounds (Table 7.8-7).

Table 7.8-7: Magnitude Ratings for Potential Auditory Impacts on Marine Fish

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Drilling and Installation Decommissioning	Non-impulsive sound (Offshore pelagic species and nearshore demersal species)	Direct AOI	Negligible	Episodic	Long-term	Negligible
	Non-impulsive sound (Offshore demersal species)	Direct AOI	Negligible	Episodic	Long-term	Negligible
Production Operations	Non-impulsive sound (Offshore pelagic species)	Direct AOI	Negligible	Continuous	Long-term	Negligible
	Non-impulsive sound (Nearshore demersal species)	Direct AOI	Negligible	Episodic	Long-term	Negligible
	Non-impulsive sound (Offshore demersal species)	Direct AOI	Negligible	Continuous	Long-term	Negligible
Drilling and Installation	Impulsive sound (Offshore pelagic species)	Direct AOI	Negligible	Episodic	Short-term	Negligible
	Impulsive sound (Offshore demersal species)	Direct AOI	Medium	Episodic	Short-term	Negligible

Impact Significance—Auditory Impacts on Marine Fish

As discussed above, pelagic species are considered to have a **Low** sensitivity due to their ability to avoid Project-related impacts. In the case of non-impulsive sound, the demersal fish species that occur within the shallow approaches to the Demerara River are also considered to have a **Low** sensitivity to vessel sound, because they are acclimated to sound from vessels transiting the Georgetown Harbour and would be capable of moving away from Project vessels, if needed. Based on the magnitude of impact and receptor sensitivity ratings described above, the premitigation- significance rating for potential auditory impacts on marine fish is **Negligible**.

7.8.3.5. Characterization of Impacts—Changes in Distribution and Habitat Usage Due to Altered Bottom Habitats and the Presence of Project Infrastructure

Fish may leave the immediate vicinity of the Project infrastructure as it is being installed to avoid localized sediment plumes and physical disturbance of the bottom habitat; however, this effect is expected to be attenuated by the availability of food in the form of injured or displaced benthos that will be temporarily more abundant and vulnerable to predation as they move away from installation sites. Demersal fish may move a few meters to avoid injury or respiratory distress from very localized sediment plumes, but many are likely to remain in the immediate vicinity to take advantage of the temporary increase in food availability.

None of the fish species that have been documented to date in the deepwater fish surveys, either with fish traps or with ROVs or drop cameras (chimeras/rattails, hagfish, lanternfish, short-tailed eel), are known to be habitat specialists. Nevertheless, some of the deepwater species from the “red fish” zone and all of the reef-associated species identified in the Lowe-McConnell study (1962; see Section 7.8.2, Existing Conditions—Marine Fish) are structure-oriented species. Evidence from the Gulf of Mexico suggests that oil rigs provide several physical habitat functions for demersal species such as snapper, grouper, and some seatrout/drum species, including refuge from currents and predators as well as foraging opportunities. The study found that the habitat value of the physical structure to a particular species was influenced to a large degree by the species’ natural depth ranges, and that a large number of species with highly varied behavioral traits can be found associating with oil rigs when such structures occur in those species’ natural depth ranges (Stanley and Wilson 1991). This suggests that over the long term, the deepwater reef-associated species that naturally occur within the PDA are likely to associate with Project infrastructure once the initial disturbance associated with construction and installation has abated. These species are expected to congregate around the wellheads and manifolds as the Project enters the production operations stage. These communities could be disturbed temporarily during decommissioning if the flowlines are disconnected from the manifolds and retrieved. However, the manifolds and well heads are expected to remain in place in perpetuity (subject to the decommissioning plan), so these facilities will continue to provide habitats for the fish community over the long term.

On the basis of the above factors, the intensity of potential impacts associated with distribution and habitat changes from altered bottom habitats and presence of Project infrastructure (relevant for demersal species only) is considered **Negligible**, especially considering the potential for localized positive effects for reef- or structure-oriented species to mitigate the initial negative effects of habitat disturbance on the demersal fish community as a whole. Some aspects of bottom habitat may change from initial post-installation conditions over time, but for the purposes of this impact assessment the changes are considered **Continuous** and **Long-term**. This yields a magnitude rating of **Negligible** for potential impacts due to altered bottom habitats and the presence of Project infrastructure (Table 7.8-8).

Table 7.8-8: Magnitude Ratings for Potential Impacts on Marine Fish from Altered Bottom Habitats and the Presence of Project Infrastructure

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Production Operations	Altered bottom habitats and presence of Project infrastructure (Offshore Demersal species)	Direct AOI	Negligible	Continuous	Long-term	Negligible

Impact Significance—Altered Bottom Habitats and Presence of Project Infrastructure

Based on the magnitude of impact and receptor sensitivity ratings described above, the premitigation- significance rating for potential impacts on marine fish due to altered bottom habitats and the presence of Project infrastructure is **Negligible**.

7.8.3.6. Characterization of Impacts—Attraction to Artificial Light

Artificial light has been known for many years to attract fish in a variety of settings, and this phenomenon has been documented around lights on offshore petroleum infrastructure (Hastings et al. 1976; Stanley and Wilson 1997; Lindquist et al. 2005). Results from studies of platforms in the northern Gulf of Mexico suggest that platforms benefit all life stages of predatory species by attracting and concentrating prey and providing sufficient light to locate and capture them (Keenan et al. 2007). While this may benefit predatory species in the short term, artificially lit structures have the potential to alter predator–prey interactions by creating conditions that favor predatory species at night and disadvantage the prey while simultaneously attracting the prey species. This could ultimately have long-term negative impacts on predatory species if localized depletion of prey resources occurs (Becker et al. 2012). The artificial light produced from the Project vessels may cause small changes in the distribution and/or behavior of fish in the immediate vicinity of the FPSO and possibly the drill ships, installation, and decommissioning vessels, but it will not be substantial enough to alter fish behavior, except in the immediate vicinity of these vessels. On this basis, the intensity of potential impacts associated with attraction to artificial light (relevant for pelagic species only) is considered **Negligible**. Light sources will be present whenever vessels are operating in the PDA or in the transit corridor between the PDA and shorebases, so the frequency of this impact is considered **Continuous** for the production operations stage in the PDA (based on the constant presence of the lighted FPSO) and **Episodic** for other stages and locations within the Direct AOI (based on the infrequent passages of Project-related vessels). Although the proportion of total light contributed by each type of vessel will vary over time, light emanating from drill ships, installation vessels, the FPSO, support vessels, offloading tankers, and tugs decommissioning vessels will occur over the entire span of the Project, so the duration of impact from artificial light is considered **Long-term**. This yields a magnitude rating of **Negligible** for potential impacts due to attraction to artificial lighting (Table 7.8-9).

Table 7.8-9: Magnitude Ratings for Potential Impacts from Attraction to Artificial Light on Marine Fish

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Development Drilling Installation Decommissioning	Attraction to artificial light (Pelagic Species)	Direct AOI	Negligible	Episodic	Long-term	Negligible
Production Operations	Attraction to artificial light (Pelagic Species)	Direct AOI	Negligible	Continuous	Long-term	Negligible

Impact Significance—Attraction to Artificial Light

Based on the magnitude of impact and receptor sensitivity ratings described above, the premitigation- significance rating for potential impacts on marine fish from attraction to artificial light is **Negligible**.

7.8.3.7. Characterization of Impacts—Entrainment in Water Intakes

Seawater will be withdrawn from the ocean to provide water to inject into the reservoir and cool the FPSO's processing equipment during the production operations stage. Larval and juvenile fish have the potential to be entrained in the intake or impinged on the screens that will be installed to remove particulates from the water before it is pumped into the treatment unit on the FPSO. Most research on entrainment and impingement involves site-specific studies at onshore power plants conducted in North American and European estuaries or nearshore coastal areas where immature fish are concentrated (Barnthouse 2013). Nearshore intakes generally pose a higher risk of entrainment and impingement than offshore intakes (WaterReUse 2011). Information on the entrainment and/or impingement rates at offshore intakes is sparse, but there is some recent evidence that losses from entrainment and impingement are insignificant at the population level, even at power plants in coastal and estuarine settings (Barnthouse 2013). The U.S. Minerals Management Service noted that coastal power plants require much higher volumes of water than individual offshore oil and gas facilities (approximately 10 million gallons per minute for a nuclear power plant; Martinez-Andrade and Baltz 2003), meaning that the entrainment losses at oil and gas facilities would likely be much lower than at power plants. In most cases, extrapolation of the losses of larval fish and eggs at power plant intakes to an equivalent number of adults indicates that entrainment losses are insignificant compared to natural and fishing-related mortality (Barnthouse 2013; WaterReUse 2011). As an embedded control, cooling and ballast water intakes on the FPSO and drill ships will be equipped with screens to reduce entrainment. On this basis, the intensity of potential impacts associated with entrainment of marine fish in water intakes is considered **Negligible**. Demand for cooling water on the FPSO will be constant and will extend through the production operations stage, so the frequency of this impact is considered **Continuous** and the duration is considered **Long-term**. This yields a magnitude rating of **Negligible** for potential impacts associated with entrainment of marine fish in water intakes (Table 7.8-10).

Table 7.8-10: Magnitude Ratings for Potential Impacts from Entrainment in Water Intakes on Marine Fish

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
All Project stages	Entrainment of early life stages (all species)	Direct AOI	Negligible	Continuous	Long-term	Negligible

Impact Significance—Marine Fish –Entrainment in Water Intakes

Based on the magnitude of impact and receptor sensitivity ratings described above, the premitigation- significance ratings for potential impacts on marine fish from entrainment in water intakes is **Negligible**.

7.8.4. Management Measures—Marine Fish

The embedded controls integrated into the Project design and operational procedures constitute the practicable measures that are available to reduce the significance of potential impacts on marine fish. Accordingly, no additional mitigation measures are proposed for marine fish. Table 7.8-11 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 7.8-11: List of Embedded Controls and Monitoring Measures

Embedded Controls
When non-aqueous drilling fluid (NADF) is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.
Where practicable, equip sound-making devices or equipment with silencers or mufflers that are enclosed, and/or use soft-start procedures (e.g., for pile driving, VSP, etc.) to reduce noise to levels that do not cause material harm or injury to marine species.
During pile-driving activities, gradually increase the intensity of hammer energy to allow sensitive marine organisms to vacate the area before injury occurs (i.e., soft starts).
For all vessel effluent discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage), comply with International Maritime Organization / International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 mg/L on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored, and the discharge meets the noted specification.
Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3°C (5.4°F) at 100 meters (approximately 328 feet) from discharge point.
Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals.
Monitor residual chlorine concentration of sewage discharges form the FPSO monthly to stay below 0.5 mg/L in accordance with MARPOL 73/78 regulations.
Perform daily visual inspections on the FPSO of discharge points to verify that there are no floating solids or discoloration of the surrounding waters.
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.
Implement chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes: • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and

– Minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.
For effluent released from the onboard sewage treatment plant, comply with aquatic discharge standards in accordance with MARPOL 73/78 regulations.
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter particle size or less) prior to discharge.
Confirm there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge. Perform daily inspections to verify no visible sheen from discharge of cooling water.
Treat bilge water in accordance with MARPOL 73/78 to comply with an oil-in-water content of less than 15 ppm, as applicable.
Provide screening for seawater intakes to avoid entrainment and impingement of marine flora and fauna.
Mitigation Measures
Following start-up of production operations, implement a program to characterize effluent water discharges from the FPSO and conduct an environmental risk assessment based on the characterization data. As appropriate based on the results of the environmental risk assessment, implement additional treatment options, if warranted and feasible.
Monitoring Measures
Prior to and post-drilling, an ROV will take pictures of the area immediately surrounding the well location to monitor for marine water quality impacts.
Monitor daily during drilling to confirm that end of well maximum weighted mass ratio averaged over all well sections drilled using NABF shall not exceed 6.9 percent wet weight base fluid retained on cuttings.
Monitor daily produced water discharge volume.
Measure oil and grease content of produced water (grab sample once per day).
Perform daily inspections to verify no visible sheen from discharge of cooling water.
Monitor discharge temperature of cooling water and produced water to avoid increases in ambient water temperature of more than 3°C (5.4°F) at 100 meters (approximately 328 feet) from point of discharge.
Use load monitoring system in the FPSO control room to support FPSO offloading.
Monitor pressure and temperature of subsea wells and manifolds by a control system on the FPSO to detect and prevent leaks.
Monitor chlorine concentration of treated sewage discharges.
Perform daily visual inspection of discharge points to verify absence of floating solids or discoloration of the surrounding waters.
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book.
Perform oil in water content (automatic) monitoring of bilge water to comply with 15 ppm MARPOL 73/78 limit and record in Oil Record Book.
Record estimated volume of ballast water discharged and location (per ballasting operation).

Table 7.8-12 summarizes the assessment of potential pre-mitigation and residual impacts on marine fish from planned Project activities. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the marine fish-specific methodology described in Sections 7.8.3.2, Magnitude and Sensitivity Definitions for Potential Impacts on Marine Fish, and 7.8.3.3, Characterization of Impacts—Changes in the Distribution of Fish Due to Altered Water Quality.

Table 7.8-12: Summary of Potential Pre-Mitigation and Residual Impacts—Marine Fish

Stage	Receptor—Impact	Magnitude of Impact Rating	Sensitivity of Receptor Rating	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project Stages	Attraction to artificial light (all vessels)	Negligible	Low (Offshore Pelagic Species) Medium (Offshore Demersal Species, Nearshore Demersal Species)	Negligible	None	Negligible
	Auditory impacts from vessel sound	Negligible	Low	Negligible	None	Negligible
Drilling and Installation	Changes in the distribution of fish due to altered water quality	Small	Low (Coastal Species, Offshore Pelagic Species) Medium (Offshore Demersal Species)	Negligible (Coastal, Offshore Pelagic Species) Minor (Offshore Demersal Species)	None	Negligible (Coastal Species, Offshore Pelagic Species) Minor (Offshore Demersal Species)
	Auditory impacts from sound from VSP and pile driving	Negligible	Low (Coastal Species, Offshore Pelagic Species) Medium (Offshore Demersal Species)	Negligible	None	Negligible

Stage	Receptor—Impact	Magnitude of Impact Rating	Sensitivity of Receptor Rating	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Production Operations	Changes in the distribution of fish due to altered water quality	Small (Offshore Pelagic Species) Negligible (Offshore Demersal Species)	Low (Coastal Species, Offshore Pelagic Species) Medium (Offshore Demersal Species)	Negligible	None	Negligible
	Changes in distribution and habitat usage due to altered bottom habitats and the presence of Project infrastructure	Negligible	Medium (Offshore Demersal Species)	Negligible	None	Negligible
	Loss of fish eggs and larvae due to entrainment of immature life stages	Negligible	Low (Coastal Species, Offshore Pelagic Species) Medium (Offshore Demersal Species)	Negligible	None	Negligible
Decommissioning	Changes in the distribution of fish due to altered water quality	Negligible	Low (Offshore Pelagic Species) Medium (Offshore Demersal Species)	Negligible	None	Negligible

7.9. MARINE BENTHOS

7.9.1. Administrative Framework—Marine Benthos

Table 7.9-1 summarizes the legislation, policies, or treaty commitments that are specifically relevant to the assessment of potential impacts on marine benthos.

Table 7.9-1: Legislation, Policies, or Treaty Commitments—Marine Benthos

Title	Objective	Relevance to the Project
Legislation		
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013; the Wild Birds Protection Act, 1987; and the Species Protection Regulations, 1999)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a framework to address the national goals for wildlife protection, conservation, and management. The Act also provides recommendations on measures for the protection of threatened ecosystems and habitats, and advises on measures for conservation of biological diversity.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity (Guyana signed in 1992 and ratified in 1994)	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Encourages Project design and execution to protect and conserve biological diversity.
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (Guyana acceded and ratified in 2010)	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection of the marine environment, especially from possible pollution.

7.9.2. Existing Conditions—Marine Benthos

The benthic communities inhabiting the Guyana Basin are influenced by the dominant environmental conditions that characterize the area, including sediment composition, water turbidity, and nutrient loads. This section describes the marine benthos and benthic habitat within the Project AOI.

7.9.2.1. Methodology

This section draws on information provided in the scientific literature, maps, AUV photographs, and field data collected by box coring and sediment profile imaging during EBSs completed in 2014, 2016, 2017, 2018, 2019, and 2020.

Sediment samples were collected from the Stabroek Block offshore Guyana as part of EBSs conducted in 2014 (Maxon Consulting and TDI-Brooks 2014), 2016 (Fugro 2016), 2017

(ESL 2018a), 2018 (Fugro 2019a), 2019 and 2020 (Appendix I, Recent Environmental Baseline Survey Reports), and as part of the EBSs in the Canje Block in 2018 (Maxon et al. 2019). The 2019 and 2020 EBSs focused on the Hammerhead PDA (Appendix I, Recent Environmental Baseline Survey Reports). The 2018 EBS (Fugro 2019a) was focused on the Payara PDA. The full 2014, 2016, and 2017 EBS reports were appended to the Liza Phase 2 Development Project EIA; the full 2018 EBS report was appended to the Payara Development Project EIA. The objectives of the EBSs were generally to characterize the physical, chemical, and biological properties of sediment and the water column, but the specific study objectives varied by study. The number of samples taken in each EBS was determined based on the specific objective of each study, as described in the above-referenced reports.

Sediment samples for benthic macrofauna community analysis were collected from 10 sampling stations during the 2014 survey, 25 sampling stations during the 2016 survey, 10 sampling stations during the 2017 survey, 8 sampling stations during the 2018 survey, and 8 sampling stations during the two Hammerhead PDA surveys. Nine sampling stations were surveyed in the Canje Block EBS. The locations of the EBS samples are depicted relative to the PDA on Figure 7.9-1. During the 2016 EBS, water and sediment samples for environmental deoxyribonucleic acid (eDNA) analysis were sub-sampled from the same 25 sampling stations described above. However, during the 2017 EBS, only water samples were collected for eDNA analysis from the nine sampling stations from three depths (surface, middle, and bottom of the water column) (ESL 2018b). Sediment sub-samples for eDNA were extracted using a sterile plastic scoop, filtered, and frozen in individual plastic bags for subsequent laboratory analysis.

Additionally, this section draws on information provided from benthic incidental catch from Year 1 and Year 2 fisheries surveys conducted from 2017 through 2019, and images collected from remotely operated vehicle (ROV) / drop cameras on select transects along the continental shelf and in the Stabroek Block.

7.9.2.2. Regional Setting

Marine benthic biological resources offshore of Guyana are poorly studied, but do not include the matrix of shallow coral reefs and seagrass meadows that are often considered emblematic of coastal tropical Atlantic environments elsewhere. This is due to the area’s highly turbid offshore conditions, which do not permit the growth of warm water corals that rely on symbiotic photosynthetic algae for nourishment.

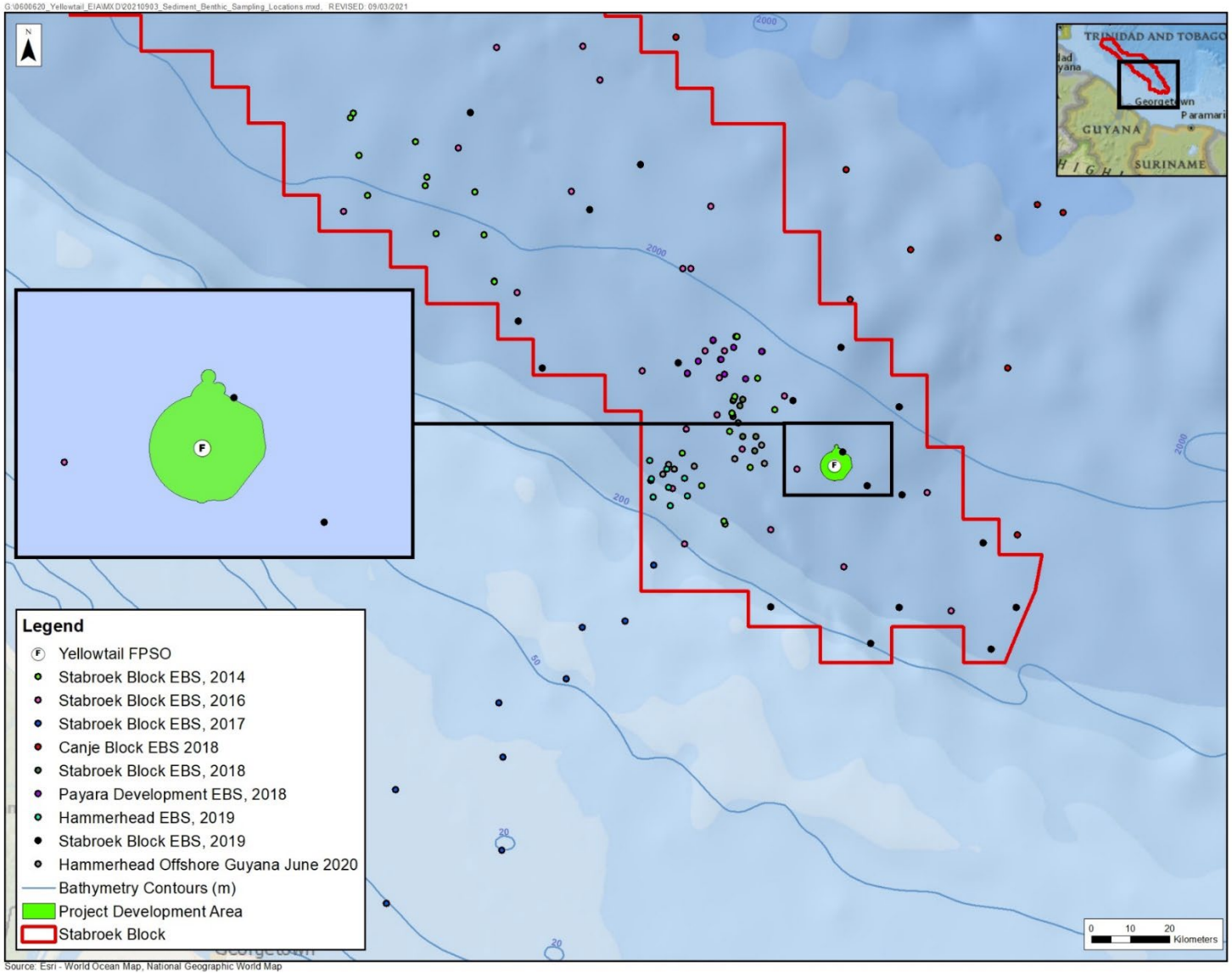


Figure 7.9-1: Locations of Benthic Sampling Stations in the Stabroek Block and along the Continental Shelf

Two cold-water coral species (*Madrepora oculata* and *Solenosmilia variabilis*) were previously known to occur offshore of Guyana. Both species occur in a wide range of depths, *M. oculata* from 55 to 1,950 meters (approximately 180 to 6,400 feet) and *S. variabilis* from approximately 219 to 2,165 meters (approximately 719 to 7,103 feet). The locations and extent of deepwater corals offshore of Guyana have not been published (Freiwald et al. 2004), but both species were documented on the shallow continental shelf based on fragments of live coral found at several locations during the 2017–2018 EEPGL-commissioned Year 1 Marine Fish Study (Figure 7.9-2). Additionally, during the Year 2 Marine Fish Study, the sampling team reported the presence of living hard corals (*M. oculata* and *S. variabilis*) in some of the trawl samples on the outer continental shelf, providing further documentation of living corals on Guyana's continental shelf.

It is unknown whether the corals represent the remnant of a long-established population or a nascent recovery. Many cold-water corals construct reefs that support highly diverse invertebrate and fish fauna (NOAA 2014). Both *M. oculata* and *S. variabilis* are technically considered reef-building corals, but *M. oculata* is particularly fragile and does not often form deepwater reefs. It more frequently occurs as a commensal[37] species living within or on reefs that were originally constructed by more robust species such as *S. variabilis*. In 2019, Fugro published an investigation of HSFs within and near the vicinity of the Payara Subsea PDA and documented the presence of a single occurrence of the black coral *Bathypathes* species (sp.) at one HSF location (Fugro 2019b).

Several species of bentho-pelagic shrimp occur in Guyanese waters, including shallow water species such as seabob (*Xiphopenaeus kroyeri*), southern brown shrimp (*Penaeus subtilis*), and white shrimp (*Penaeus schmitti*). The red-spotted shrimp (*Penaeus brasiliensis*) and the southern pink shrimp (*P. notialis*) are found in deeper waters (EPA 2010). While these species are free-swimming, they are often found at or near the bottom. To date, three macrobenthic species, giant isopod (*Bathynomus giganteus*), red deepsea crab (*Chaceon quinquedens*), and flatback lobster (*Stereomastis sculpta*) have been documented to occur in the Stabroek Block.

Other species that are common to deepsea Caribbean environments, and may be present but have yet to be documented in the Stabroek Block, include several species of isopods (such as *Leptanthura guianae* and *Malacanthura truncata*) (Poore and Schotte 2009, 2015) and amphipods (including *Ampelisca mississippiana*, and *Thaumastasoma* sp.). There are also numerous species of annelids, including the polychaetes *Tharyx marioni*, *Aricidea suecia*, *Levinsenia uncinata*, and *Paraonella monilaris*, as well as bivalves such as *Vesicomya vesical* and *Heterodonta* sp. (Wei et al. 2010).

[37] Living in close association, such that one species benefits without harming the other

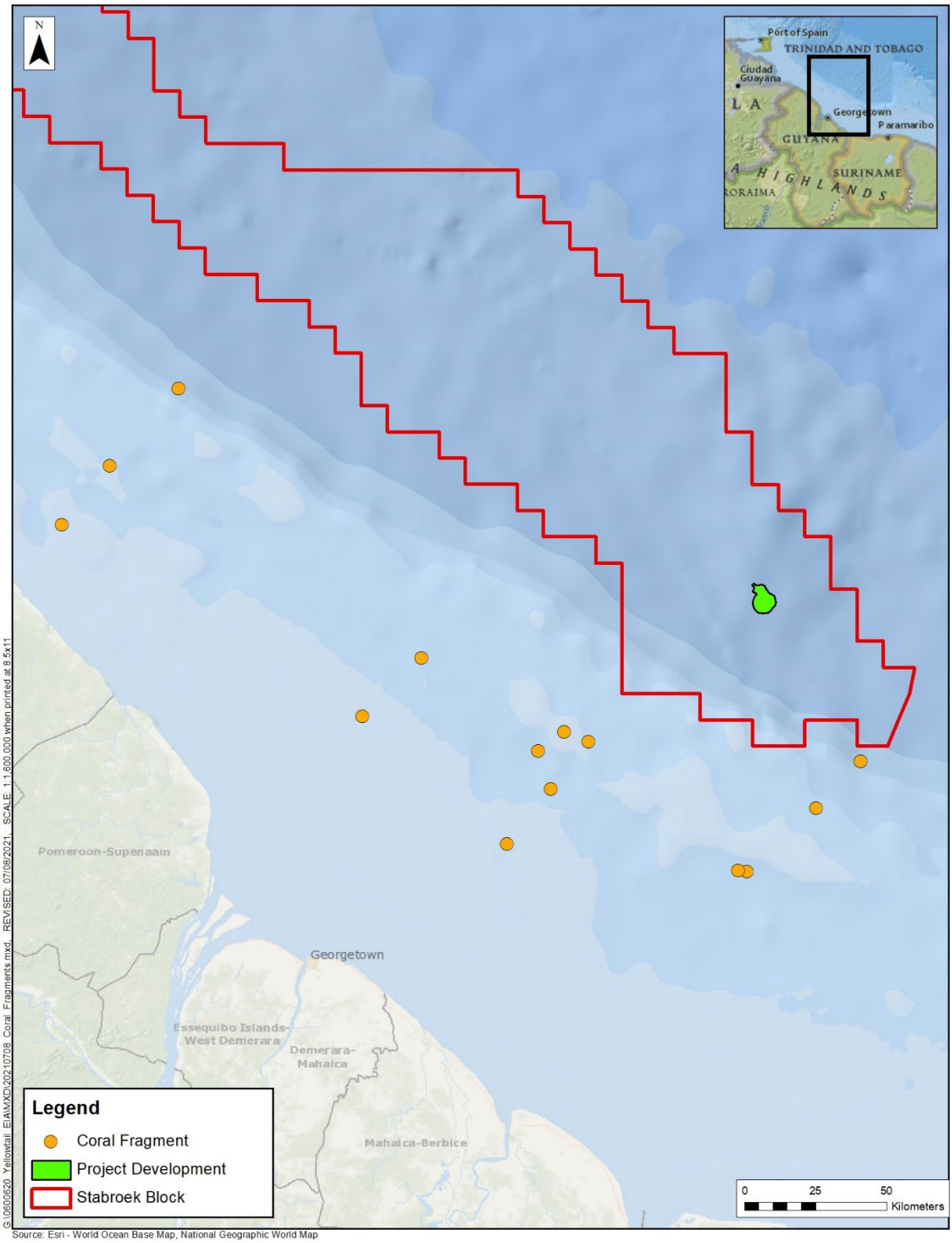


Figure 7.9-2: Locations Where Live Coral Fragments Were Found on the Continental Shelf during 2017–2019 Fish Surveys

7.9.2.3. Existing Conditions in the Project Development Area

Environmental Baseline Survey Data

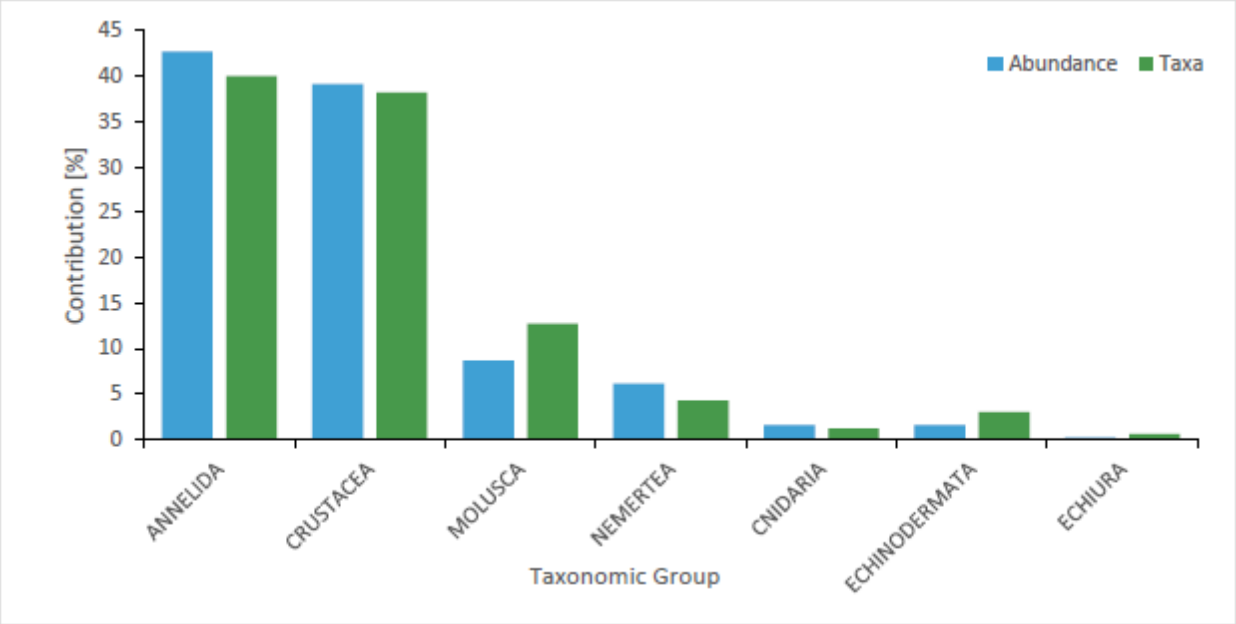
EBS samples are an effective means of sampling small, common, infaunal organisms because they cover a small area and penetrate into the sub-seafloor strata. The EBSs conducted to date in the Stabroek Block emphasized water and sediment sampling, but also included benthic biological components because benthic infauna (macrofauna) communities are a useful indicator of environmental health due to their relative sensitivity to changes in sediment physical and chemical conditions.

Results of the 2014 EBS revealed that the total abundance of benthic infauna from near the PDA northwest across the Stabroek Block (see Figure 7.9-1) was low, averaging 116 ± 32.4 organisms per square meter; (Maxon Consulting and TDI-Brooks 2014). This organism density is below the range of typical abundances reported from other continental slopes (Rowe et al. 1982; Flach et al. 1999). The observed low density of macrofauna is likely related to limited organic food sources, as indicated by the low organic carbon content in the sediment (see Section 6.3.2.3, Marine Sedimentology).

The most abundant major taxonomic groups from the 2014 EBS were polychaete worms, crustaceans, and mollusks. The overall prevalence of these three groups is typical for marine sediments. Polychaetes were the numerically dominant group identified (average density 47 per square meter, representing 41 percent of the total groups). Polychaetes typically comprise about half of all species and a third of macrofaunal species from deepwater marine habitats worldwide. Aside from polychaetes, no other individual major taxa were abundant, with each of the other taxa groups individually representing less than 14 percent of total abundance. During the 2014 EBS, 50 distinct families were identified with approximately half represented by either one or two individuals. This is a relatively high level of diversity considering the low abundance of macrofauna. Dominant families were typical cosmopolitan inhabitants of shelf and slope sediments worldwide. These included spionid, cirratulid, paraonid polychaetes, phoxocephalid amphipods, and thyasirid and nuculanid (bivalve) mollusks (Maxon Consulting and TDI-Brooks 2014).

Similar to the 2014 data, the 2016 EBS data showed an overall prevalence of annelids (including polychaetes), crustaceans, and mollusks typical for marine sediments as well as low macrofaunal densities from near the PDA northwest across the Stabroek Block (see Figure 7.9-1). The 2016 samples were divided into two 0.1 square meter (m^2) (1.1 square feet [ft^2]) sub-samples, and density averaged 20 organisms per 0.1 m^2 (1.1 ft^2). Extrapolation to a density per square meter for comparison to the 2014 data equates to 200 organisms per square meter, but such comparisons are of limited analytical value given the small number of sub-samples analyzed in 2016. While the 2014 survey did not categorize the macrofauna organisms beyond the family level, the 2016 EBS further classified the macrofauna to the order and species level and covered a larger sampling area. Results from the 2016 sampling showed macrofaunal communities within the survey area to be diverse. In 2016, a total of 165 taxa were identified across seven phyla and 27 families, with 36 identified to species level (including

15 species of polychaetes, 10 crustaceans, 8 mollusks, and 3 sipunculid worms). Annelida were the numerically dominant group (phylum), in terms of species composition (40 percent) and abundance (42.7 percent). Crustaceans accounted for the second highest species composition (38.2 percent) and abundance (39.1 percent), followed by mollusks (12.7 percent and 8.7 percent, respectively) and other taxa (collectively 9.1 percent and 9.5 percent, respectively) (Figure 7.9-3; Fugro 2016).



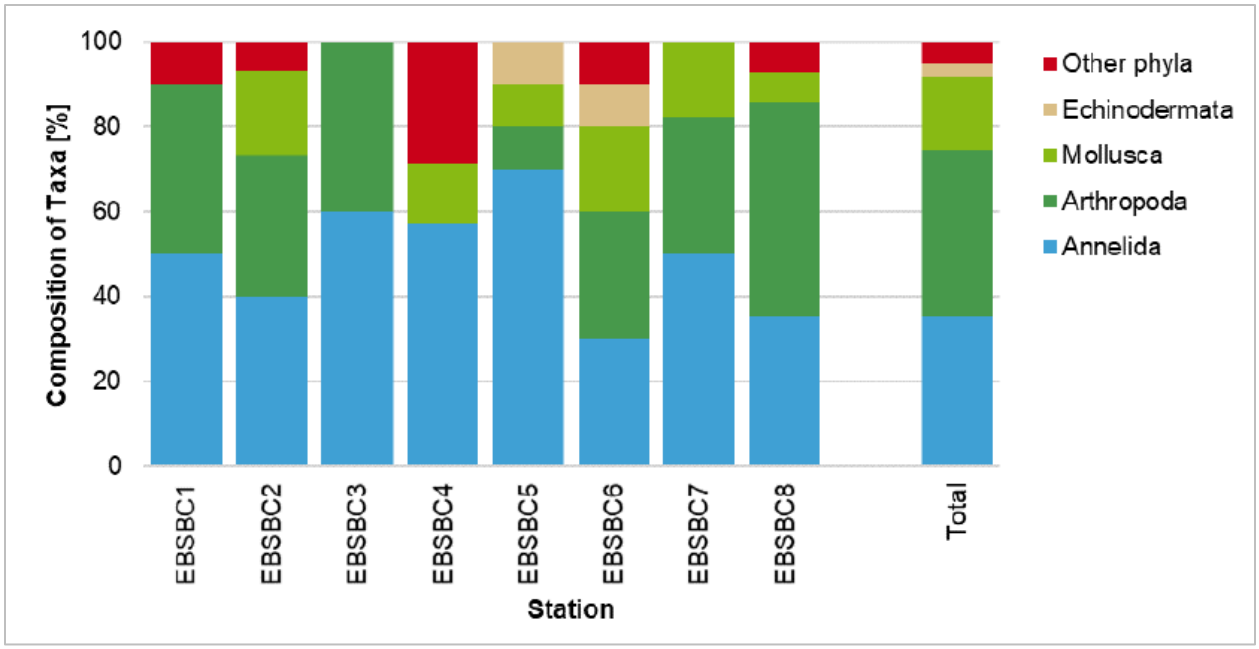
Source: Fugro 2016

Figure 7.9-3: Abundance and Taxa of Major Taxonomic Groups Identified in 2016 Environmental Baseline Survey

The 2017 EBS, conducted south of the PDA in comparatively shallow water on the continental shelf (see Figure 7.9-1), showed a sample density ranging from 8 to 932 organisms per 0.1 m^2 (1.1 ft^2), with an average of 136.7 organisms per 0.1 m^2 (1.1 ft^2). For the purpose of comparison to 2014 and 2016 data, this equates to approximately 1,367 organisms per square meter. This reflects a higher abundance of organisms on the continental shelf (sampled in 2017) compared to the area sampled in the Stabroek Block (sampled in 2014 and 2016). A total of 11 phyla were identified, with arthropods being the most prevalent, followed by annelids (polychaetes). Within these 11 phyla, a total of 133 taxa and 4,101 specimens were identified (ESL 2018a).

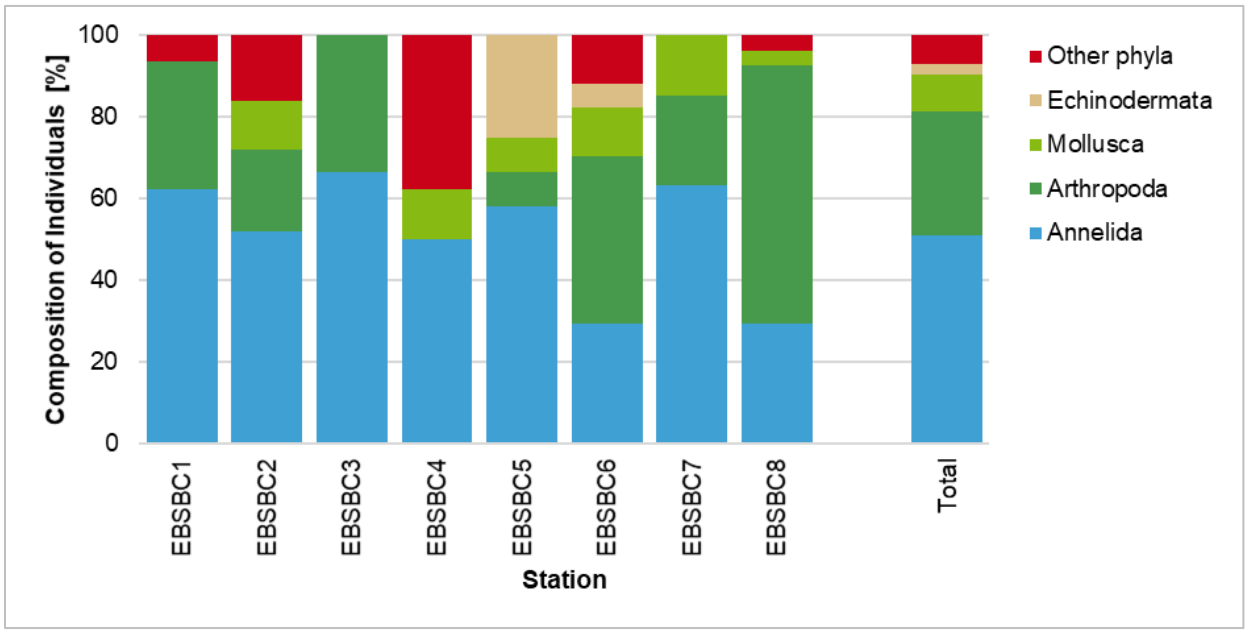
The 2018 EBS (Fugro 2019a) was focused on the Payara PDA and the immediate surrounding area (also west of the PDA; see Figure 7.9-1). Data from this survey showed a deep-sea macrofaunal community similar to that recorded in the Liza field in the 2016 EBS (Fugro 2016). A total of 59 taxa were identified (the data were rationalized to account for juveniles, pelagic, colonial, or damaged individuals), with annelids (51 percent) being the most prevalent, followed by arthropods (30.3 percent), mollusks (9 percent), echinoderms (2.6 percent), and other taxa

(7.1 percent) (Fugro 2019a). Figure 7.9-4 and Figure 7.9-5 illustrate the composition of taxa and individuals for each sampling station in the 2018 EBS.



Source: Fugro 2019a

Figure 7.9-4: Phyletic Composition of Taxa Identified in 2018 Environmental Baseline Survey

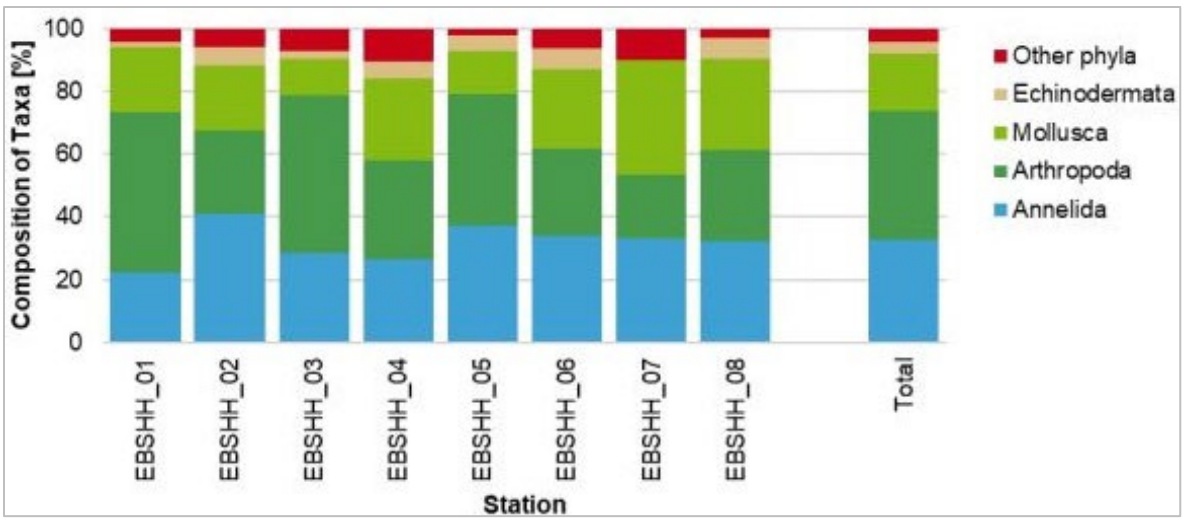


Source: Fugro 2019a

Figure 7.9-5: Phyletic Composition of Individuals Identified in 2018 Environmental Baseline Survey

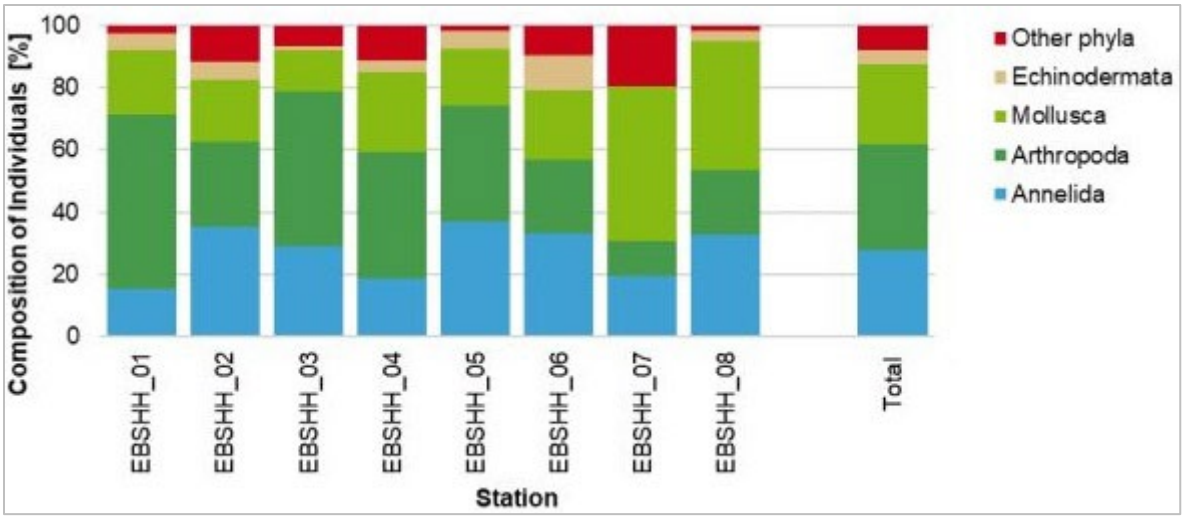
The macrofaunal abundances surveyed in 2018 within the Payara PDA vicinity are considered low. In the Payara PDA vicinity, the faunal community within the survey area was found to be relatively diverse and non-dominated, with a large number of taxa occurring in relatively low abundances. Moderate to high variability was demonstrated across the survey area, with polychaete worms and arthropods the most numerous taxa recorded (Fugro 2019a). One arthropod individually recorded and classified as *Aspidoniscus* sp. A, as well as three arthropod individuals recorded and classified as *Heteromesus*, are considered likely to be new records of these species (Fugro 2019a).

The most recent EBS studies from the Stabroek Block were conducted in 2019 and 2020 across the southeastern portion of the Stabroek Block as part of the Hammerhead Development. Reports from these studies are included as Appendix I, Recent Environmental Baseline Survey Reports. Samples collected in the Hammerhead April/May 2019 survey documented moderately diverse communities with overall low mean abundances. Arthropods and annelids were the most numerous taxa recorded, similar to findings recorded in the Payara, Liza 1, and Liza 2 Field PDAs (Appendix I, Recent Environmental Baseline Survey Reports). The number of individuals per 0.2 m^2 (2.2 ft^2) ranged from 27 to 77. In total, 477 individual animals and 140 benthic taxa were collected, of which 57 (40.7 percent) were arthropods, 46 (32.9 percent) were annelids, 26 (18.6 percent) were mollusks, 5 (3.6 percent) were echinoderms and 6 (4.3 percent) were other phyla, specifically sea anemones (within the phylum Cnidaria), ribbon worms (Nemertea), and peanut worms (Sipuncula). Statistical analysis of these data demonstrated moderate to higher variability across the survey stations than in prior EBS surveys, likely a result of high numbers of taxa and low numbers of individuals across samples. No correlations were observed between the macrofaunal community and the physico-chemical parameters sampled across the Hammerhead survey area. Figure 7.9-6 and Figure 7.9-7 illustrate the composition of taxa and individuals for each sampling station.



Source: Appendix I, Recent Environmental Baseline Survey Reports

Figure 7.9-6: Phyletic Composition of Taxa Identified in the 2019 Hammerhead Environmental Baseline Survey



Source: Appendix I, Recent Environmental Baseline Survey Reports

Figure 7.9-7: Phyletic Composition of Individuals Identified in the 2019 Hammerhead Environmental Baseline Survey

Eight survey stations were also sampled for sediment macrofauna in March 2020 within the Hammerhead area (Appendix I, Recent Environmental Baseline Survey Reports), collecting a total of 204 individuals across 37 total taxa from eight phyla. The overall infauna density ranged from 98.0 to 359.2 individuals per square meter, with a mean density of 208.2 ± 79.3 individuals per square meter. Annelids comprised the majority of sampled organisms (60.3 percent), followed by arthropods (19.6 percent) and nematodes (17.2 percent). This taxonomic assemblage is similar to the assemblage described from the 2018 Liza 2 Field Development EBS (Benthic USA 2019). Annelids were also the most abundant infaunal taxon (24) followed by arthropods (6), and echinoderms (2). The phyla Sipunculida, Nematoda, Nemertea, Mollusca, and Chordata were each represented by a single taxon. Community-wide measures of density (average 208 m^2 [2,239 ft^2]) and abundance were generally low when compared with other deep-sea areas in similar water depths (Grassle and Maciolek 1992; Oliver et al. 2011), and were lower than the average infauna density of 359 individuals per square meter from the 2018 Liza 2 Field Development EBS (Benthic USA 2019). Measures of diversity including total taxa, species richness, and species diversity were also low relative to previously surveyed areas in the Stabroek Block.

In addition to EBS studies conducted in the Stabroek Block, a 2018 EBS was also completed for the Canje Block (Maxon et al. 2019), located south and east of the lower Stabroek Block. EBS sampling of the benthic community in the Canje Block took place in September 2018 at nine locations ranging in depth from 1,925 to 3,078 meters (6,316 to 10,098 feet). The EBS data identified a total of 441 organisms and exhibited an average abundance of 490 organisms per square meter. This abundance is low compared to values reported from various continental slope and basin habitats worldwide. Abundances were significantly and negatively correlated with total organic carbon. The most abundant major taxonomic group was nematodes (>50 percent), followed by polychaetes, crustaceans, and cnidarians. The macrofaunal

community comprised 73 taxa and 45 families. This diversity is relatively high considering the low abundance of the macrofauna collected. Dominant families were typical cosmopolitan inhabitants of shelf and slope sediments worldwide.

Table 7.9-2 summarizes macrofauna families identified in surveys conducted from 2014, 2016, 2017, 2018, 2019, and 2020. Macrofauna data were not categorized beyond the family level beginning in 2014, and data analysis and comparisons thereafter were also completed at the family level for consistency.

Table 7.9-2: Macrofauna Families Observed in 2014, 2016, 2017, 2018, 2019, and 2020 Environmental Baseline Surveys

Phylum	Class	Order	Family
Annelida	Polychaeta	Unidentified	Unidentified
		Amphinomida	Amphinomidae
		Eunicida	Dorvilleidae
			Eunicidae
			Lumbrineridae
			Oenonidae
			Onuphidae
		Phyllodocida	Acoetidae
			Eulepethidae
			Glyceridae
			Goniadidae
			Hesionidae
			Nephtyidae
			Nereididae
			Pholoidae
			Phyllodocidae
			Pilargidae
			Polynoidae
			Sigalionidae
			Syllidae
		Sabellida	Oweniidae
		Spionida	Longosomatidae
			Spionidae
			Magelonidae
			Serpulidae
			Poecilochaetidae
			Trochochaetideae
		Terebellida	Cirratulidae
			Ampharetidae
			Fauveliopsidae
			Flabelligeridae
			Terebellidae

Phylum	Class	Order	Family
			Trichobranchidae
		Scolecida	Orbiniidae
			Paraonidae
			Capitellidae
			Maldanidae
			Opheliidae
			Orbiniidae
			Chaetopteridae
			Scalibregmatidae
		Eunicida	Lumbrineridae
			Onuphidae
	Clitellata	Enchytraeida	Enchytraeidae
Arthropoda	Arachnida	Prostigmata	Microtrombidiidae
	Hexanauplia	Calanoida	Aetideidae
			Bathypontiidae
			Calanidae
			Centropagidae
			Clausocalanidae
			Heterorhabdidae
			Lucicutiidae
			Metridinidae
			Paracalanidae
			Scolecitrichidae
			Temoridae
		Cyclopoida	Cyclopidae
			Oithonidae
		Harpacticoida	Tachidiidae
		Poecilostomatoid	Corycaeidae
			Oncaeidae
			Sapphirinidae
		Scalpelliformes	Scalpellidae
		Sessilia	Balanidae
	Insect	Coleoptera	Dermestidae
		Diptera	Empididae
		Lepidoptera	Nymphalidae
	Malacostraca	Amphipoda	Ampeliscidae
			Aoridae
			Caprellidae
			Chevaliidae
			Corophiidae
			Isaeidae
			Ischyroceridae

Phylum	Class	Order	Family
			Lysianassidae
			Oedicerotidae
			Photidae
			Phoxocephalidae
			Platyischnopidae
			Scopelocheiridae
			Synopiidae
			Unknown Amphipod
		Cumacea	Bodotriidae
			Diastylidae
			Nannastacidae
			Unidentified
		Decapoda	Axiidea*
			Brachyura*
			Paguroidea*
			Alpheidae
			Anomura*
			Callianassidae
			Caridea*
			Crangonidae
			Decapoda*
			Diogenidae
			Micheleidae
			Palaemonidae
			Panopeidae
			Pasiphaeidae
			Pilumnidae
			Pinnotheridae
			Porcellanidae
			Processidae
			Pseudorhombilidae
			Sergestidae
		Euphausiacea	Euphausiidae
		Isopoda	Anthuridae
			Anthuroidea*
			Cirolanidae
			Desmosomatidae
			Gnathiidae
			Haploniscidae
			Hyssuridae
			Idoteidae
			Ischnomesidae

Phylum	Class	Order	Family
			Leptanthuridae
			Macrostylidae
			Nannoniscidae
			Serolidae
		Leptostraca	Nebaliidae
		Mysida	Mysida
		Tanaidacea	Unidentified
			Agathotanaidae
			Apseudidae
			Apseudomorpha*
			Colletteidae
			Kalliapseudidae
			Leptocheliidae
			Metapseudidae
			Neotanaidae
			Parapseudidae
			Paratanaidae
			Tanaellidae
			Tanaidomorpha*
			Typhlotanaidae
	Ostracoda	Halocyprida	Halocyprididae
		Myodocopida	Myodocopid
	Pycnogonida	Pantopoda	Phoxichilidiidae
Brachiopoda	Lingulada	Lingulida	Lingulidae
Bryzoa	Gymnolaemata	Cheilostomatida	Celleporidae
			Scrupariidae
Chordata	Actinopterygii	Ophidiiformes	Bythitidae
	Anthrozoa	Amphioxiformes	Branchiostomatidae
	Ascidiacea	Unidentified	Unidentified
Cnidaria	Anthozoa	Actiniaria	Diadumenidae
			Edwardsiidae
		Spirularia	Cerianthidae
		Zoantharia	Zoantheria
	Hydroz	Leptothecata	Campanulariidae
			Lafoeidae
			Sertulariidae
		Siphonophorae	Agalmatidae
		Siphonophorae	Clausophyidae
		Siphonophorae	Diphyidae
		Trachymedusae	Geryoniidae
Echinodermata	Holothuroidea	Holothuroidea	Holothuroidae
		Apodida	Synaptidae

Phylum	Class	Order	Family
	Ophiuroidea	Ophiurida	Amphiuridae
			Ophiocomidae
			Ophiuridae
			Ophiuroidae*
Hemichordata	**	**	**
Mollusca	Bivalva	Venerida	Mactridae
		Lucinida	Ungulinidae
		Cardiida	Cardiidae
			Semelidae
			Tellinidae
		Limida	Limidae
		Lucinida	Lucinidae
			Thyasiridae
		Myida	Corbulidae
		Nuculida	Nuculidae
			Sareptidae
		Nuculanida	Nuculanidae
			Yoldiidae
		Ostreida	Pteriidae
		Pectinida	Pectinidae
		Venerida	Arcticidae
	Caudofoveata	Chaetodermatida	Limifossoridae
	Gastropoda	Littorinimorpha	Naticidea
			Eulimidae
		Neogastropoda	Muricidae
			Olividae
	Scaphopoda	Dentaliida	Dentaliidae
Nematoda	Unidentified	Unidentified	Unidentified
	Adenophorea	Desmodorida	Haliplectidae
		Desmoscolecida	Desmoscolecidae
		Enoplida	Campgdoridae
		Enoplida	Rhabdodemaniidae
		Monhysterida	Diplopeltidae
			Linhomoeidae
			Monhysteridae
			Siphonolaimidae
			Sphaerolaimidae
		Trichocephalida	Trichinellidae
	Chromadorea	Araeolaimida	Aulolaimidae
	Secernentea	Tylenchida	Paratylenchidae
Nemertea	Not assigned	Not assigned	Not assigned
Porifera	**	**	Porifera

Phylum	Class	Order	Family
Sipuncula	Phascolosomatidea	Aspidosiphonida	Aspidosiphonidae
	Sipunculidea	Golfingiiformes	Unidentified
			Golfingiidae
			Phascolionidae
	**	**	Sipuncula

Source: Maxon Consulting and TDI-Brooks 2014; ESL 2018a; Fugro 2016, 2019a; Appendix I, Recent Environmental Baseline Survey Reports

Notes: "Not assigned" indicates that the scientific community has not assigned the organism to a taxon at that taxonomic rank. The symbols "*" and "**" and the term "unidentified" refer to the surveyors' inability to identify an organism at that taxonomic rank.

The macrofaunal communities documented to date within the Stabroek and Canje blocks are typical of deep-sea sedimentary habitats. Overall, the macrofaunal abundances surveyed within the Stabroek and Canje blocks were lower compared to values reported from various continental slope and basin habitats worldwide, but diversity varied across the surveyed areas. The 2017 survey reported a relatively high density and diversity of organisms, although densities observed varied widely between individual samples. The 2019 Hammerhead study reported both lower abundance and diversity, but high evenness across samples. The 2020 Hammerhead survey reported low densities, but relatively high diversity, with statistical analysis identifying higher abundances of several taxa at shallower stations (Appendix I, Recent Environmental Baseline Survey Reports). Typically, continental slope sediments exhibit a decline in macrofaunal abundance with depth in response to declining food availability (Maxon et al. 2019) but the difference in community assemblage between the shallow and deep Hammerhead stations may also be partly driven by sediment characteristics (Appendix I, Recent Environmental Baseline Survey Reports).

Environmental DNA Samples

In addition to direct sampling of whole benthic organisms and subsequent analysis of those specimens by traditional morphological means, the 2016 and 2017 surveys also included collection of complimentary eDNA samples. These samples were used to estimate the presence and absence of organisms from DNA found in the environment. Initial studies of eDNA analysis in seawater show that the approach captures the fish diversity better than or equal to contemporary survey methods (Thomsen et al. 2012; Kelly et al. 2014); however, further studies are needed to validate the eDNA approach in marine environments (Thomsen and Willerslev 2015; Kelly et al. 2014). Morphological analysis of the 2016 survey samples identified 197 distinct taxa[38] (Fugro 2016). In 2017, survey samples identified specimens from 133 taxa in 11 phyla (ESL 2018a). The eDNA analysis was partially consistent with the morphological analysis, as all of the phyla and 117 of the distinct taxa were confirmed through DNA analysis (CEGA 2019). The DNA data were also consistent with the 2016 and 2017 morphological data in terms of taxonomic dominance. The three data sets identified annelids and arthropods as dominant taxa, although the DNA samples also contained large numbers of taxa in the bacteria, fungi, and hydrozoa (jellyfish and corals) phyla. Other groups where several species were

[38] These taxa were mostly identified to the species rank, but some were only identifiable to family level.

identified included bony fish, snails and slugs, shrimp, stingray, sea anemone, sea cucumber and starfish, bivalves, squids, and sponges.

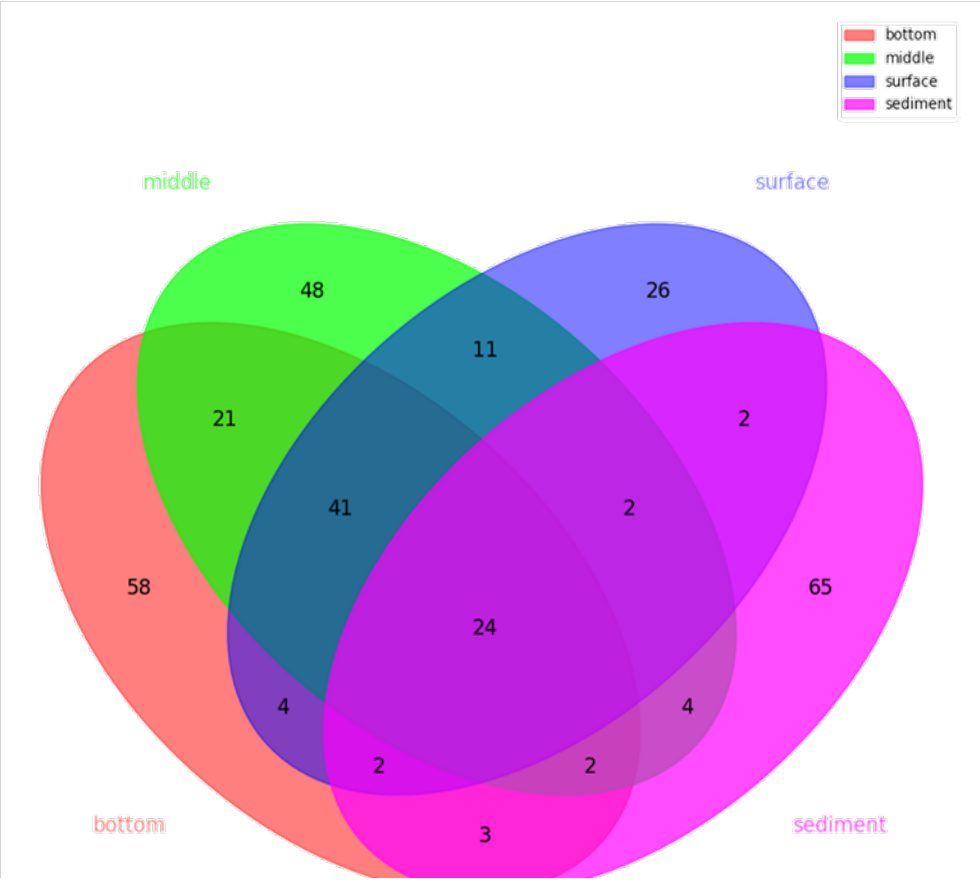
Most of the remaining taxa that were identified from the morphological analysis but not identified in the eDNA analysis have not had their DNA sequence information entered into a reference database (CEGA 2019). In addition to these taxa, 48 taxa detected and identified to at least the genus rank in the eDNA analysis were not documented at the class level or higher in the morphological analysis (see Table 7.9-3).

The results from the 2016–2017 eDNA analysis revealed a total of 503,075 amplicon sequence variants[39] in water and sediment samples. Matching the eDNA to a reference library resulted in the identification of 552 genera (248 from Metazoa[40]) and 618 families (298 from Metazoa). Of these, 408 species were identified (CEGA 2019). These results were then compared to the 2016 and 2017 EBS data, where benthic species were identified by taxonomists (morphological approach). In most cases, the eDNA analysis was able to identify specimens down to the species level, whereas only family level or higher identifications were achieved using the morphological approach. These findings are summarized in Table 7.9-3.

The eDNA study examined sediment samples and water samples taken from three depths of the water column: surface, middle, and bottom. The most unique sample type was sediment, which not only had a high number of species not found elsewhere (65), but also showed little overlap with the other sample types. While the water samples also had unique species, there was a high degree of overlap with the other sample types (Figure 7.9-8). The analysis found that collecting water from the middle and bottom of the water column captures more than 70 percent of the total identifiable diversity. However, eliminating one or more sample type would result in not capturing taxa that may be important from a bio-indicator perspective (CEGA 2019).

[39] Amplicon sequence variant is a term used to refer to individual DNA sequences recovered from a marker gene analysis following the removal of spurious sequences generated during amplification and sequencing of a DNA segment. They are inferred sequences of true biological origin.

[40] Metazoa is a grouping of organisms that comprises all animals other than protozoans and sponges. Metazoa are multicellular animals with differentiated tissues.



Source CEGA 2019

Blue = water from the surface of the water column; Green = water from the middle of the water column; Orange = water from the bottom of the water column; Pink = sediment samples, which have the largest number of unique species as well as the least overlap with the other sample types.

Figure 7.9-8: Venn Diagram of the Different Sample Types

Table 7.9-3: Taxonomic Groups Identified at the Species Level in Sediment and Seawater Samples using eDNA Analysis

Phylum	Class	Species	2016-2017 Environmental Baseline Survey Morphological ID
Annelida	Polychaeta	*Alciopina* sp.	
		Aricidea sp.	*Aricidea* sp.
		Cossura candida	
		Eunice impexa	*Eunicida, Onuphis* sp.
		Eunice sp.	*Eunicida, Onuphis* sp.
		Hyalinoecia sp.	
		Laetmonice producta	
		Laonice sp.	Laonice (?)
		Lumbrineris latreilli	Lumbrineridae sp. A
		Onuphis iridescens	Onuphis, Onuphidae
		Owenia fusiformis	
		Phyllodoce groenlandica	Phyllodocidae
		Phyllodoce longipes	Phyllodocidae
		Poecilochaetus serpens	*Poecilochaetus fulgoris* (?)
		Sipunculus nudus	
		Sternaspis scutata	
		Terebella lapidaria	
		Terebellides stroemii	
		Travisia pupa	Travisia
		Typhloscolex sp.	
Arthropoda	Arachnida	*Demodex folliculorum*	
	Branchiopoda	*Macrothrix* sp.	
	Collembola	*Paronellides praefectus*	
	Hexanauplia	*Acartia longiremis*	Copepoda, Hexanauplia, Calanoida
		Acartia tonsa	
		Acrocalanus andersoni	
		Acrocalanus longicornis	

Phylum	Class	Species	2016-2017 Environmental Baseline Survey Morphological ID
		Aegisthidae sp.	
		Ameira scotti	
		Anthessius sp.	
		Bradya sp.	
		Calocalanus curtus	
		Calocalanus minutus	
		Calocalanus styliremis	
		Candacia pachydactyla	
		Centropages furcatus	
		Centropages violaceus	
		Clausocalanus arcuicornis	
		Clausocalanus furcatus	
		Clausocalanus parapergens	
		Clausocalanus paululus	
		Corycaeidae sp.	
		Ctenocalanus vanus	
		Cyclopina gracilis	
		Euchaeta marina	
		Hemicyclops thalassius	
		Heterorhabdus papilliger	
		Lucicutia flavicornis	
		Mecynocera clausi	
		Miracia efferata	
		Mormonilla sp.	
		Nannocalanus minor	
		Oithona nana	
		Oithona plumifera	
		Oithona similis	
		Oithona sp.	

Phylum	Class	Species	2016-2017 Environmental Baseline Survey Morphological ID
		Oithonidae sp.	
		Oncaea prendeli	
		Oncaea sp.	
		Oncaea waldemari	
		Paracalanus aculeatus	
		Paracalanus indicus	
		Paracalanus quasimodo	
		Paracalanus tropicus	
		Pleuromamma abdominalis	
		Pseudocalanus moultoni	
		Sapphirina scarlata	
		Sapphirinidae sp.	
		Scaphocalanus magnus	
		Subeucalanus pileatus	
		Temora stylifera	
		Temora turbinata	
		Triconia elongata	
		Triconia minuta	
		Triconia umerus	
		Undinula vulgaris	
	Insecta	*Attagenus smirnovi*	
		Cryptolestes ferrugineus	
		Diptera sp.	
		Rhagoletis zephyria	
	Malacostraca	*Belzebub faxoni*	
		Euphausia americana	Euphausiidae
		Penaeus brasiliensis	
		Porcellio scaber	Porcellionidae
	Ostracoda	*Halocypris inflata*	Myodocopida

Phylum	Class	Species	2016-2017 Environmental Baseline Survey Morphological ID
		Howeina sp.	
		Porroecia spinirostris	
		Proceroecia microprocera	
Chaetognatha	Sagittoidea	*Sagitta enflata*	
		Sagitta helenae	
Chordata	Actinopteri	*Antigonia capros*	Actinopterygii
		Argyropelecus affinis	
		Bregmaceros sp.	
		Cheilopogon cyanopterus	
		Cheilopogon exsiliens	
		Diaphus dumerilii	
		Diaphus garmani	
		Exocoetidae sp.	
		Maurolicus weitzmani	
	Elasmobranchii	*Dasyatis americana*	
		Hypanus guttatus	
	Thaliacea	*Brooksia lacromae*	
		Doliolum nationalis	
		Iasis cylindrica	
Cnidaria	Anthozoa	*Diadumene leucolena*	Actinaria (burrowing), Actinaria (epibenthic)
		Nanozoanthus harenaceus	
		Stylophora pistillata	
	Hydrozoa	*Agalma okeni*	Cnidaria
		Aglaura hemistoma	
		Amphogona apicata	
		Athorybia rosacea	
		Branchiocerianthus imperator	
		Cordagalma cordiforme	
		Diphyes bojani	

Phylum	Class	Species	2016-2017 Environmental Baseline Survey Morphological ID
		Diphyes dispar	
		Geryonia proboscidalis	
		Lensia campanella	
		Lilyopsis fluoracantha	
		Nanomia bijuga	
		Nectopyramis sp.	
		Obelia bidentate	
		Rosacea cymbiformis	
		Rosacea sp.	
		Solmundella bitentaculata	
		Sulculeolaria quadrivalvis	
		Varitentacula yantaiensis	
	Scyphozoa	*Atolla vanhoeffeni*	
Ctenophora	Tentaculata	*Pleurobrachia bachei*	
Echinodermata	Holothuroidea	*Enypniastes eximia*	Echinodermata
	Ophiuroidea	*Ophiolepis elegans*	Ophiuroidea sp. A, Ophiuroidea sp. B
		Ophiura cf. ljungmani	
Gastrotricha	N/A	*Chaetonotus neptuni*	
		Heterolepidoderma loricatum	
		Platydasys sp.	
		Tetranchyroderma sp.	
		Urodasys sp.	
Hemichordata	Enteropneusta	*Meioglossus psammophilus*	Hemichordata
Kinorhyncha	Cyclorhagida	*Echinoderes horni*	
		Sphenoderes poseidon	
Mollusca	Bivalvia	*Idas argenteus*	Bivalvia
	Caudofoveata	*Chaetoderma feld*	Caudofoveata
	Cephalopoda	*Abralia* sp.	
		Heteroteuthis dagamensis	

Phylum	Class	Species	2016-2017 Environmental Baseline Survey Morphological ID
		Ornithoteuthis antillarum	
	Gastropoda	*Cavolinia uncinata*	Gastropoda sp. A, Gastropoda sp. B, Gastropoda sp. C, Gastropoda sp. D, Neogastropoda
		Cliopsis krohni	
		Diacavolinia longirostris	
		Limacina inflata	
		Parvanachis obesa	
Nematoda	Chromadorea	*Cynura klunderi*	Nematoda
		Daptonema procerus	
		Halicephalobus sp.	
Nemertea	Enoplea	*Eumonostilifera* sp.	
		Tetrastemma sp.	
		Phanoderma sp.	
	Palaeonemertea	*Tubulanidae* sp.	
	Pilidiophora	*Hubrechtidae* sp.	
		Micrura ignea	
Platyhelminthes	Catenulida	*Paracatenula* sp.	
	Rhabditophora	*Odontorhynchus aculeatus*	
		Paromalostomum fusculum	
		Prosthiostomum acroporae	
		Psammorhynchus tubulipenis	
Porifera	Demospongiae	*Halisarca dujardini*	Porifera

Source: CEGA 2019

Notes:

1. The data are presented at the taxonomic level provided in CEGA 2019.
2. A positive taxonomic assignment was determined when there was an unambiguous match at 98% identity (or better) across 99% (or more) of the query sequence.
3. Organisms listed are not the dominant taxa but instead those to which the environmental genomics analysis could assign a species name.
4. This table lists identified Metazoan species. However, other taxa were assigned names at higher taxonomic levels (e.g., class, order, or family).
5. Listed in the "2016-2017 Environmental Baseline Survey Morphological ID" column are groups that were also found in the morphology-based analyses and the corresponding ID is provided.

Benthic Bycatch from Year 1 and 2 Fish Surveys

The deepwater samples from Year 1 (2017 and 2018) fish surveys produced three benthic species, giant isopod, red deepsea crab, and flatback lobster, none of which were captured in the 2014, 2016, or 2017 EBSs. Giant isopods were overwhelmingly the most prevalent benthic organism caught in the deepsea traps. Over 100 individuals were caught in a single trap in some locations, and baits were entirely consumed by the time some traps were retrieved, indicating that higher catches may have been attained if more bait had been used. Neither giant isopods nor red deep-sea crabs were documented to be present in Guyanese waters prior to this survey (Liverpool et al. 2018), although both species are widespread in the temperate and tropical western Atlantic Ocean (Lowry and Dempsy 2006; Liverpool et al. 2018). There were no apparent spatial or seasonal patterns in the distribution of these species other than their apparently uneven distribution across the study area.

No deepwater benthos were captured in the Year 2 fish surveys (2018 and 2019), but the survey reported the presence of living hard corals (*Madrepora oculata* and *Solenosmilia variabilis*) in some of the trawl samples (trawling consists of dragging one or more nets over the seafloor) at depths from 110 to160 meters (361 to 525 feet) on the outer continental shelf. This corroborated similar findings from the first year of the study, which produced the first scientific evidence of living corals on Guyana's continental shelf. As noted in the Year 1 report for the Marine Fish Study (ERM 2018), it is unknown whether the corals represent the remnant of a long-established population or a nascent recovery of a previously degraded community.

ROV Footage and Seabed Photography

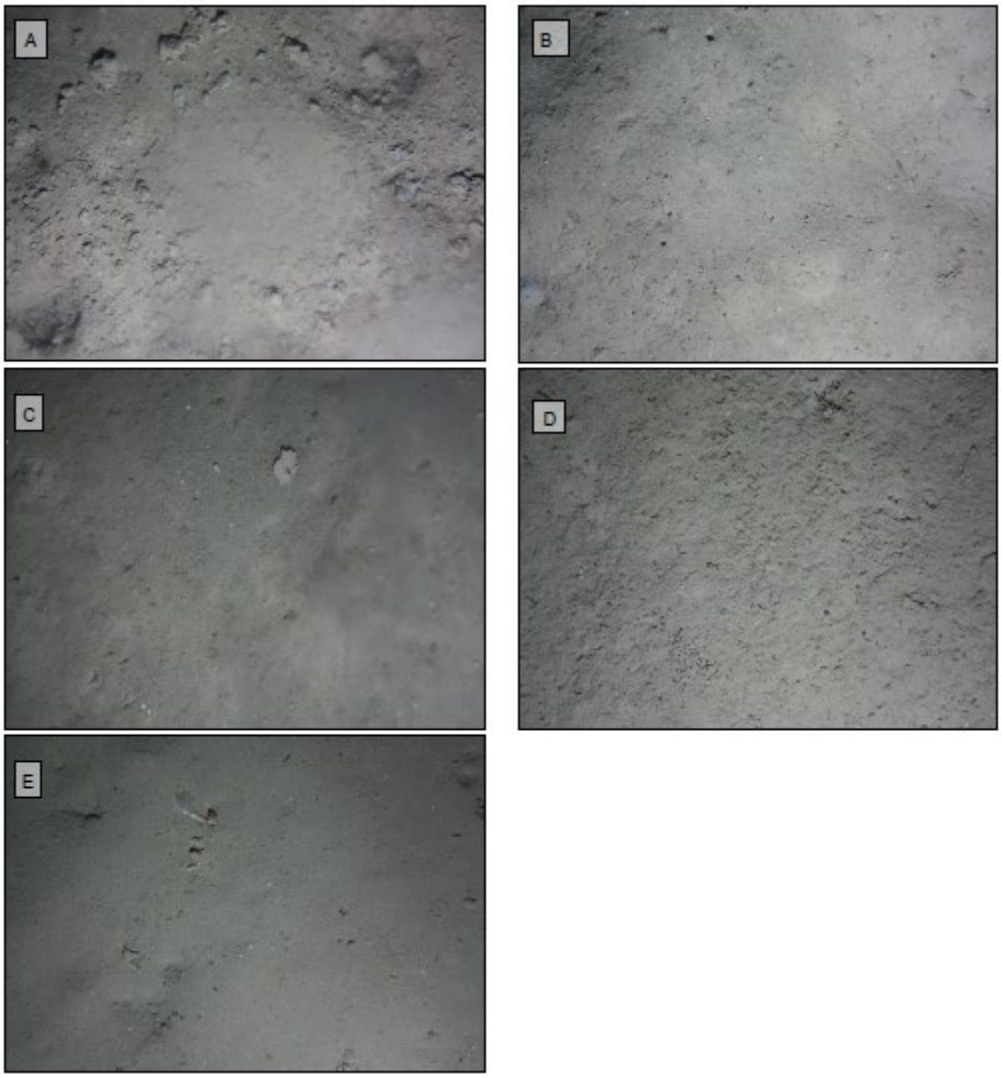
Benthic imagery from the Stabroek Bock is available from five surveys. A 2014 survey produced a limited number of still images of macrobenthos from drop cameras; a 2016 survey produced a mosaic of still images of the seafloor; and a 2017 ROV survey produced approximately 9 hours of video of the seafloor. A 2018 AUV survey produced approximately 8,500 kilometers (5,282 miles) of survey line of side scan sonar survey data and 14,000 seafloor photographs of HSFs (all of which were outside the Yellowtail PDA; see Section 6.3, Marine Geology and Sediments). A 2019 AUV survey produced photographs and videos at nine surveyed locations.

The seabed photography from the 2016 survey indicated that the survey area primarily consists of one broad benthic habitat type: sublittoral sediment (EUNIS[41] code A5). This marine benthic habitat can encompass a wide range of sediments from boulders, cobbles, pebbles and shingles, coarse sands, sands, fine sands, muds, and mixed sediments (Davies et al. 2004). The footage from the 2017 ROV survey is broadly consistent with the findings of the 2016 survey. Each sediment type hosts characteristic biological communities, which together define biotopes. Within the sublittoral sediment habitat, one biotope was identified: circa-littoral sandy mud (A5.35) with aspects of deep-sea mud. Benthic epifauna were scarcely observed in the photographs taken in 2016; however, the 2017 ROV footage showed some areas with abundant

[41] The European Nature Information System (EUNIS) is a habitat classification system developed by the European Environment Agency in collaboration with international experts. The EUNIS includes all types of natural and artificial habitats, both aquatic and terrestrial.

evidence of active infauna, including holes and sediments that had been disturbed, likely by invertebrates burrowing into the substrate or sifting the surficial sediments for edible material. Figure 7.9-9 provides representative photographs of the circa-littoral sandy mud biotope taken from five of the 2016 sample stations. Epifauna were sparse in the photographs and videos, but evidence of habitation (bioturbation) by tube-building polychaetes (possibly Sabellidae and Terebellidae), burrowing shrimp, and foraminifera can be observed in all of the seafloor images. Mud shrimp burrows were evident in most photographs, and some photographs showed other taxa including tusk shells, gastropods, and hydroids.

No deepwater coral growth was detected in the 2014, 2016, or 2017 EBS or in the ROV surveys within the Stabroek Block (Maxon Consulting and TDI-Brooks 2014; Fugro 2016; ESL 2018b); however, black coral (Bathypathes sp.) was identified at one HSF during the 2018 AUV survey and a number of coral taxa including bottlebrush black coral (Tanacetipathes sp.), sea whips (Octocoralia), wire coral (Stichopathes sp.), branching stony coral (Scleractinia), and unidentified soft coral (Alcyonacea) were documented during the 2019 AUV surveys in the Hammerhead area (Appendix I, Recent Environmental Baseline Survey Reports; also see Figure 7.9-14). As stated in Section 7.9.2.2, Regional Setting, two cold-water coral species (*Madrepora oculata* and *Solenosmilia variabilis*) were documented on the shallow continental shelf based on fragments of live coral found at several locations during the 2017-2018 fish survey (Figure 7.9-10). In addition, one species of octocoral (*Anthomastus* sp.) was documented in the deepwater portion of the Stabroek Block based on a single ROV observation that occurred near the Liza-3 exploration well, approximately 31 kilometers (19 miles) southeast of the planned location of the Yellowtail FPSO. *M. oculata* and *S. variabilis* have been documented from the outer continental shelf south of the Stabroek Block.



Source: Fugro 2016

Photo A: Station NC21_BCE002—mud, tube-building polychaetes and amphipods, mud shrimp burrows, Scaphopoda (tusk shells), gastropods, foraminiferans
Photo B: Station NC21_BCE004—sandy mud, tube-building polychaetes and amphipods, mud shrimp burrows, foraminiferans, unidentified hydroid
Photo C: Station NC21_BCE005—sandy mud, tube-building polychaetes and amphipods, foraminiferans, Scaphopoda
Photo D: Station NC21_BCE024—sandy mud, tube-building polychaetes and amphipods, foraminiferans
Photo E: Station NC21_BCE025—muddy sand, Sabellids and other tube-building polychaetes, mud shrimp burrows, foraminiferans

Figure 7.9-9: Representative ROV Photographs of Benthic Habitat from the Stabroek Block

Source: ERM 2018

Figure 7.9-10: Live Black Coral Fragments from Guyana's Continental Shelf

Photographs of live benthic macrofauna on the seafloor include a few opportunistic photos taken during the 2014 survey, a small number of still images extracted from the deepwater ROV footage in 2017 (see Figure 7.9-11). Neither giant isopods nor flatback lobsters have been captured in live footage in the Stabroek Block to date; however, they are known to occur in the block on the basis of their capture in the deepwater fish survey, and the isopods are believed to be locally common in at least some parts of the block based on the high numbers that were captured in the deepwater fish traps. Representative photos of giant isopods are included on Figure 7.9-12.

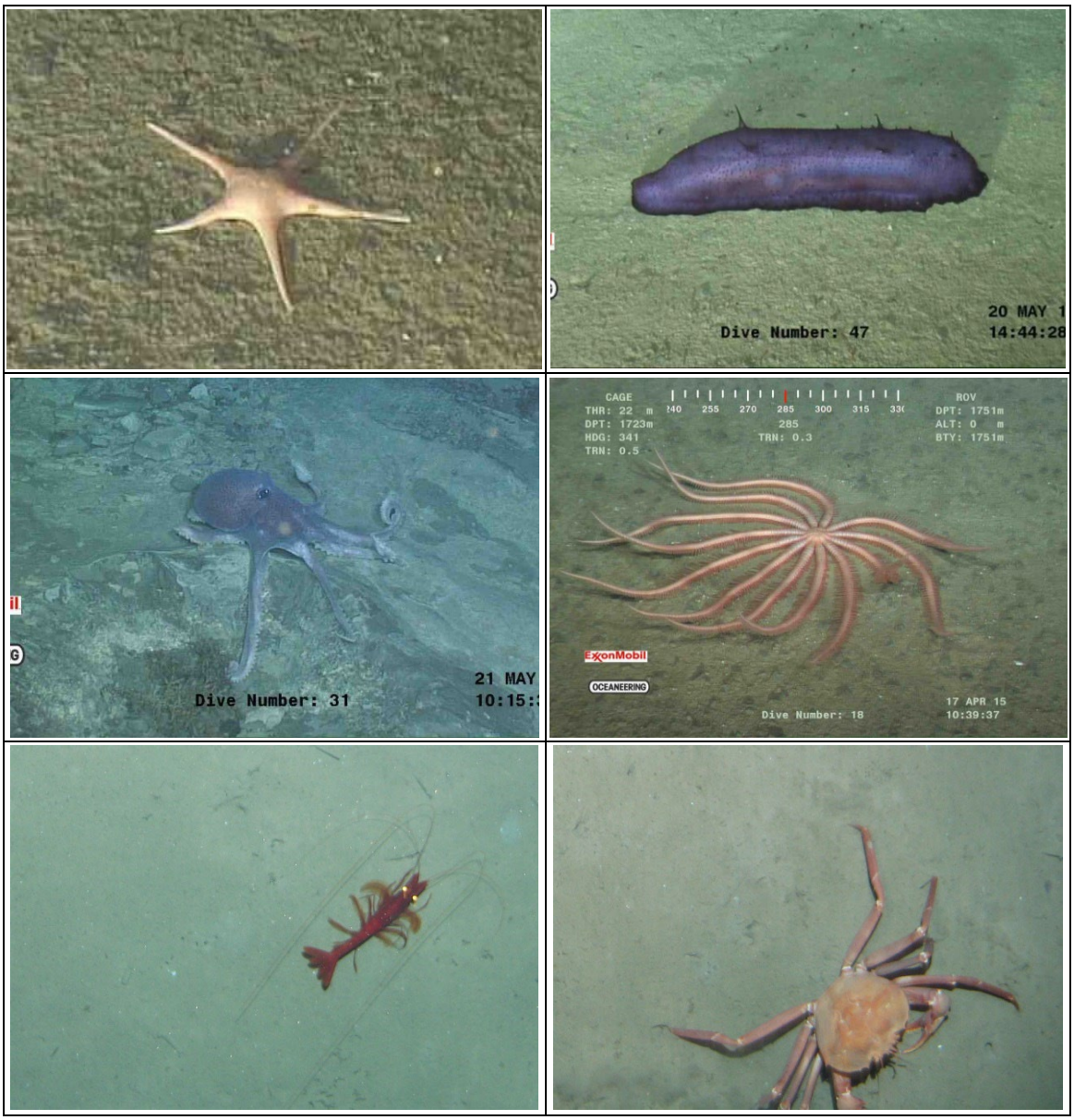
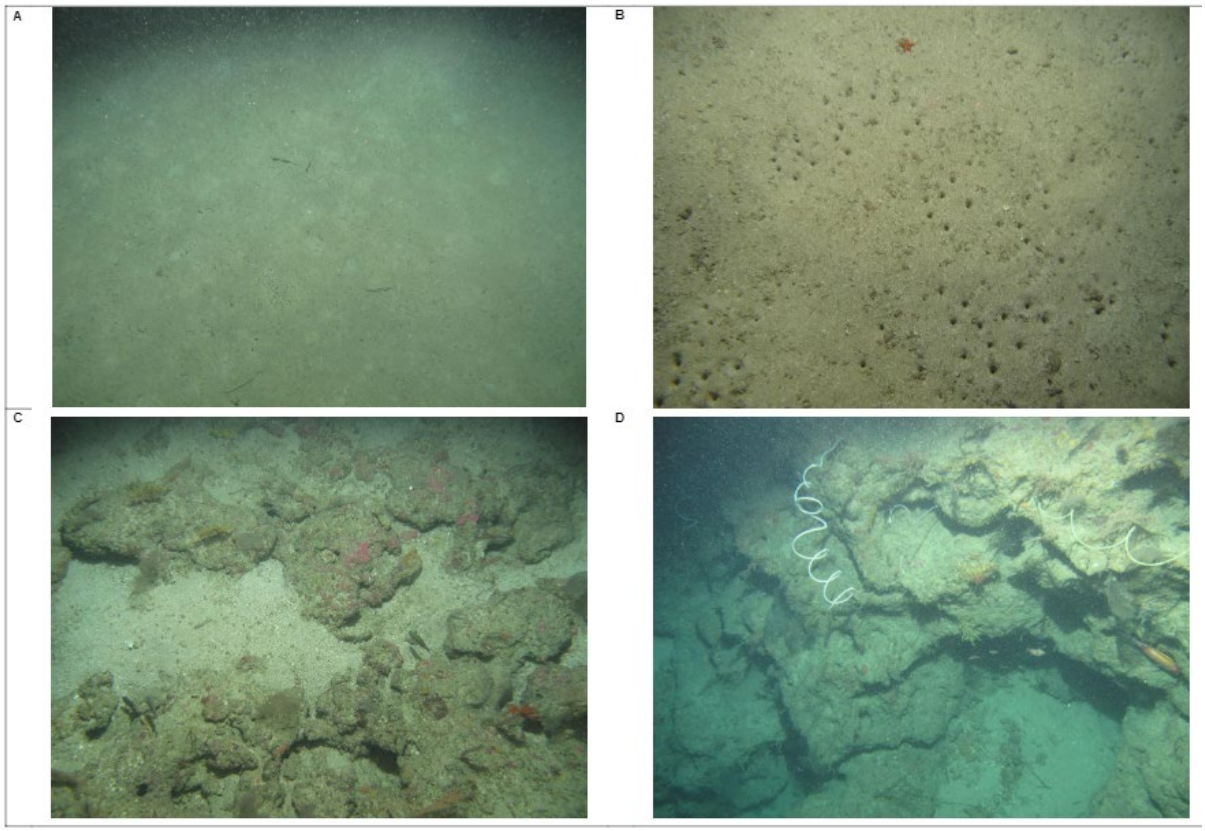


Figure 7.9-11: Representative ROV Photographs of Macrobenthos from the Stabroek Block

Figure 7.9-12: Representative Photographs of Macrobenthos from Deepsea Traps in the Stabroek Block

The 2019 Hammerhead survey of the continental shelf (Appendix I, Recent Environmental Baseline Survey Reports), using photographic data collected from 15 survey points in the Hammerhead area, documented low abundance and diversity of the epifaunal communities (animals living on the surface) within the soft seabed. Sessile taxa such as burrowing anemones (Cerianthidae), sea cucumber (Holothuroidea), carnivorous sponge (*Chondrocladia* sp.), sea pens (Pennatulacea), and buried xenophyophores (Xenophyophoroidea) were documented. Mobile taxa were rarely observed and included shrimp (Caridea) and unidentified fish (Pisces). Fauna documented in the deep-sea floor and deep-sea muddy sand habitats was predominantly comprised of sessile taxa (See Figure 7.9-13). Mobile taxa such as pencil urchin (Cidaridae), small-unidentified fish (Pisces), starfish (Asteroidea), and sea cucumbers (Holothuroidea) were occasionally observed. Faunal burrows arranged in a honeycomb formation were frequently observed. Sessile taxa were more diverse in areas of 'deep-sea rock and artificial hard substrata,' and included sponges (Porifera), coralline algae (Corallinales), sea fan (Gorgoniidae), sea whip (Octocorallia), faunal turf (Bryozoa/Hydrozoa/Porifera), black coral (Antipatharia, including *Stichopathes* sp. and *Tanacetipathes* sp.) and stony coral (Scleractinia). Mobile taxa recorded were dominated by echinoderms including brittlestars (Ophiuroidea) and sea urchins (Diadematidae) (Figure 7.9-14).



Source: Appendix I, Recent Environmental Baseline Survey Reports

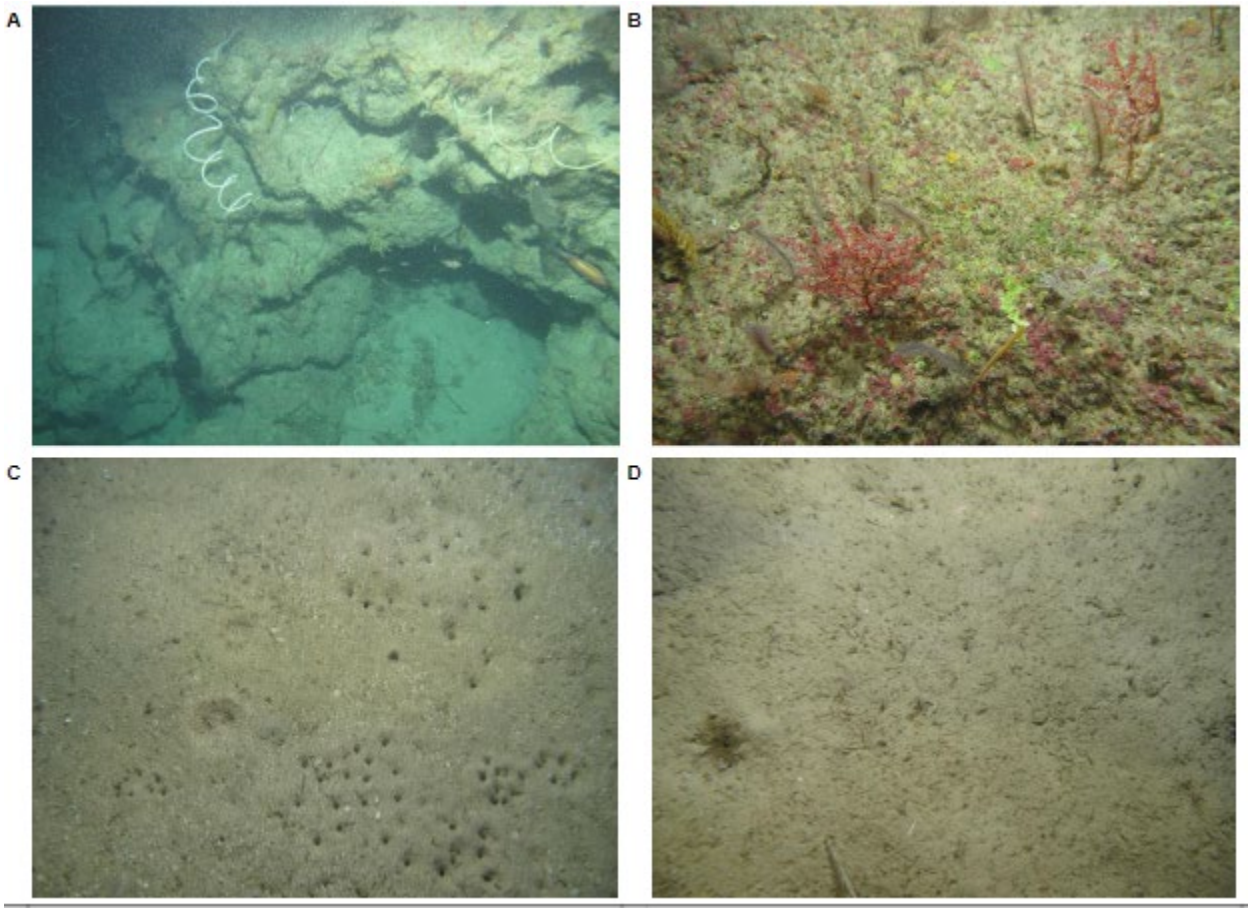
Photo A: Photograph EBSHHDD_03_01. Sublittoral soft seabeds. Sediment: Mud with minimal shell material. Fauna Description: Burrowing anemone (Cerianthidae), shrimp (Caridea), unidentified fish (Pisces), faunal tubes and burrows

Photo B: Photograph TR02_45. Deep-sea floor. Sediment: Gravelly, muddy sand. Fauna Description: Small unidentified fish (Pisces), pencil urchin (Cidaridae), possible soft coral (Alcyonacea), starfish (Asteroidea). Small faunal holes in honeycomb formation.

Photo C: Photograph TR02_45. Deep-sea rock and artificial hard substrata. Sediment: Exposed, elevated bedrock interspersed with gravelly muddy sand. Fauna Description: Coralline algae (Corallinales), encrusting yellow sponge (Porifera), black coral including bottlebrush black coral (*Tanacetipathes* sp.), sea fan (Gorgoniidae), sea whip (Octocorallia), wire coral (*Stichopathes* sp.), branching stony coral (Scleractinia), soft coral (Alcyonacea), reef dwelling fish (Pisces), faunal turf (Hydrozoa/Bryozoa/Porifera), tube dwelling worms (Sabellidae/Serpulidae), clavate soft coral (Alcyoniidae), brittlestar (Ophiuroidea)

Photo D: Photograph TR05_23. Deep-sea rock and artificial hard substrata. Sediment: Exposed, elevated bedrock. Fauna Description: Coralline algae (Corallinales), encrusting yellow sponge (Porifera), black coral including bottlebrush black coral (*Tanacetipathes* sp.), wire coral (*Stichopathes* sp.), branching stony coral (Scleractinia), reef dwelling fish (Pisces)

Figure 7.9-13: Representative Seabed Sediment Photographs of Hammerhead Area



Source: Appendix I, Recent Environmental Baseline Surveys
Photo A: Whip coral, sponges, faunal turf, soft coral; Photo B: Black coral, crustose algae, brittlestar, sponge; Photo C: Faunal burrows; Photo D: Faunal Burrows

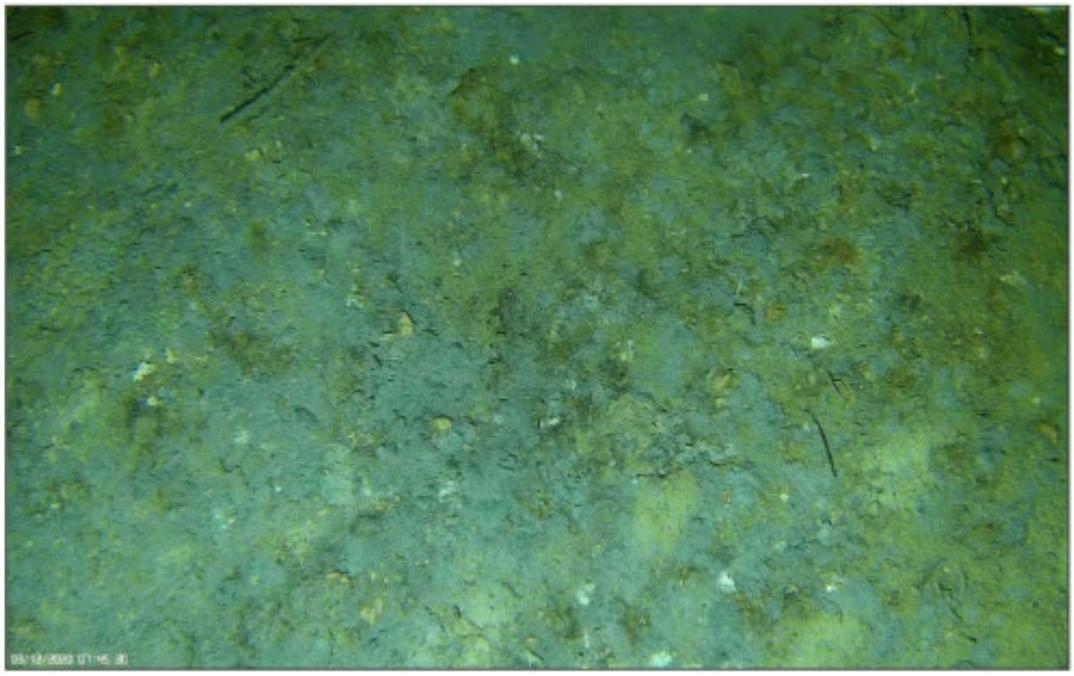
Figure 7.9-14: Representative Seabed Sediment Photographs of Hammerhead Area

High-definition videographic and photographic data were also collected in the 2020 survey of the Hammerhead Area (Appendix I, Recent Environmental Baseline Survey Reports), which documented soft bottom substrate composed of silt and clay, and a relatively depauperate biological assemblages throughout the PDA (See Figure 7.9-15). No fish or invertebrate benthos were observed in the images, likely because of the small overall visual sampling area (approximately 1 m^2 [10.8 ft^2]) at each station. Images collected at Station HH-02 were indicative of surficial sediments strongly influenced by discharges of drilling muds and cuttings from previous drilling activities (see Figure 7.9-16); however, these effects of the previous drilling activities appeared to be localized and did not appear to be widespread across the survey area.

Source: Appendix I, Recent Environmental Baseline Survey Reports

Representative seafloor image at Station HH-04 with sediments predominantly silt and loose clay; irregular surface topography appears to be biologically active with subtle bioturbations (i.e., small burrows).

Figure 7.9-15: Representative Photograph of the Seabed in Hammerhead Area



Source: Appendix I, Recent Environmental Baseline Survey Reports

Representative seafloor image at Station HH-02 with benthic habitat characterized by surficial sediment of predominantly silt and loose clay. Surficial sediments have an odd, mottled appearance with formations of small clumps of clayey materials and incorporated organic materials. Based on the sediment sampling results at this station, it is very likely the content of the surficial sediments is strongly influenced by discharges of drilling muds and cuttings.

Figure 7.9-16: Photograph of Seabed Disturbance in Hammerhead Area

As described in Section 7.9, Marine Benthos, multiple EBSs have been conducted in the Stabroek Block, including the 2019 EBS, which was conducted along the northern boundary of the Yellowtail PDA. While no other EBS data have been collected specifically within the Yellowtail PDA, the collection of more than 60 samples over several years throughout the Stabroek Block has demonstrated that benthic communities in the block are relatively homogeneous and that the deep-sea environment of the block is relatively stable. The fauna collected over this period on the deep-sea floor have consistently been identified as cosmopolitan; predominantly sessile taxa, including polychaete worms and mollusks, and observations of fish and more mobile taxa have been uncommon. Photography and videography of bottom composition have documented most survey areas as primarily consisting of soft, unconsolidated sediments that provide little structure or diversity of habitat. Images captured of the seafloor throughout the block consistently show mostly silt, clay, and mud, and relatively depauperate biological communities. The similar habitat characteristics and fauna documented across survey years and locations indicate these findings are typical and representative of the deep-sea floor environment of the Stabroek Block. For these reasons, the Consultants consider the data presented in this section adequate to support an assessment of the Project's likely impacts on marine benthos.

7.9.3. Impact Assessment—Marine Benthos

This section addresses the potential impacts on marine benthic biological resources (i.e., benthos) resulting from planned Project activities. The key potential impacts assessed include injury to benthos as a result of deposition of drill cuttings (via smothering, filter fouling, and/or toxicity impacts from residual oil contained on discharged cuttings), injury or disturbance of benthos as a result of disturbance of the seafloor during installation of Project components, and changes to benthic habitat as a result of the initial placement of Project components on the seafloor, as well as the abandonment-in-place of additional components during decommissioning.

7.9.3.1. Relevant Project Activities and Potential Impacts

The PDA is located in the eastern portion of the Stabroek Block in water depths ranging from approximately 1,725 to 1,925 meters (approximately 5,660 to 6,315 feet). As described above, this area's macrofauna community is dominated by polychaete worms and crustaceans as the most abundant major taxonomic groups, followed by mollusks and other taxa. Benthic microepifauna were generally scarce in the EBS samples, with the exception of tube-building polychaetes (possibly Sabellidae and Terebellidae) and burrowing shrimp; however, red crabs and giant isopods were locally abundant as bycatch in deepwater fish samples collected in nearby areas of the Stabroek Block.

The Project has the potential to cause localized impacts on benthos through smothering and/or filter fouling (from deposition of drill cuttings), toxicological impacts (from non-aqueous drilling fluid [NADF] adhered to deposited cuttings), and crushing or displacement (from placement of subsea infrastructure). These potential impacts will be balanced somewhat by the creation of artificial substrate in the form of manifolds, wellheads, and other infrastructure permanently installed on the seafloor, which will have the potential to benefit benthos by providing additional hard substrate for colonization.

Table 7.9-4 summarizes the Project stages and activities that could result in potential Project impacts on marine benthos.

Table 7.9-5: Summary of Relevant Project Activities and Key Potential Impacts—Marine Benthos

Stage	Project Activity	Key Potential Impacts
Development Well Drilling	Discharge of drill cuttings, resulting in increased total suspended solids (TSS) concentrations in water column and deposition of cuttings on seafloor	• Smothering of benthos as a result of accumulation of drill cuttings • Increased TSS concentrations in water column, potentially contributing to health impacts on filter-feeding marine benthos • Toxicological impacts on benthos from NADF adhered to deposited drill cuttings • Crushing of benthos where subsea infrastructure is placed
SURF/FPSO Installation	Installation of FPSO anchor structures and SURF infrastructure on the seafloor	

Stage	Project Activity	Key Potential Impacts
Production Operations	Presence of (non-moving) infrastructure on the seafloor	• Creation of artificial substrate for use by benthos during production operations (positive)
Decommissioning	Abandonment of infrastructure on the seafloor	• Creation of artificial substrate for use by benthos indefinitely (positive)

7.9.3.2. Assessment of Impacts

The assessment of the Project's magnitude of potential impacts on marine benthos is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on marine benthos is defined according to the definitions provided in Table 7.9-5.

Table 7.9-5: Definitions for Intensity Ratings for Potential Impacts on Marine Benthos

Criterion	Definition
Intensity	Negligible: No anticipated injury to marine benthos.
	Low: Some measurable injury to marine benthic communities anticipated, but not to the extent that there is an impact on the viability of an entire benthic community or population.
	Medium: Injury to marine benthos anticipated at a moderate scale. Entire communities or populations may be affected, but impacts are not likely to result in a permanent change to the structure or species composition of an entire benthic community or population.
	High: Significant injury to marine benthos anticipated, to the extent that permanent changes to an entire community structure/species composition are likely.

The sensitivity of marine benthos varies among species according to their habitat preferences and behavior. Table 7.9-6 provides definitions for the receptor sensitivity ratings for potential impacts on marine benthos.

Table 7.9-6: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Marine Benthos

Criterion	Definition
Sensitivity	Low: No taxa within the benthic community known to possess unique susceptibilities to Project-related impacts. Known taxa are readily able to avoid and/or recover quickly from Project-related impacts.
	Medium: One or a limited number of taxa within the benthic community with elevated susceptibility to Project-related impacts, and/or known taxa exhibit a habitat preference or behavior that limits their ability to avoid Project-related impacts, but representing a small fraction of the overall community.
	High: Several taxa within the benthic community with elevated susceptibilities to Project-related impacts and known taxa exhibit habitat preferences or behaviors that greatly limits to their ability to avoid Project-related impacts, representing a substantial fraction of the overall community.

7.9.3.3. Characterization of Impacts—Injury Due to Drill Cuttings Deposition

Magnitude of Impact—Injury Due to Drill Cuttings Discharge

Planned discharges of drill cuttings and fluids could potentially impact marine benthos as a result of increases in total suspended solids (TSS) concentrations in the water column, burial and smothering under cuttings accumulated on the seafloor, and exposure to toxins in disturbed sediment or NADF adhered to the accumulated cuttings.

With regard to potential physical impacts, discharged drill cuttings will accumulate on the seafloor close to the individual wells, and some benthic fauna will likely be impacted through burial and smothering. Smothering is a biological impact on benthos induced by the physical impact of burial (Hendrick et al. 2016). The severity of burial impacts depends on the sensitivity of the benthic organism, the thickness of deposition, the amount of oxygen-depleting material (and the resulting anoxic conditions beneath the depositional layer), and the duration of the burial. Thickness thresholds vary by species and sediment permeability. A threshold deposition rate of 5 centimeters (2 inches) per month for smothering impacts on benthic communities is recommended based on publications by Ellis and Heim (1985) and MarLIN (2019). Smaller threshold values (as low as 1 millimeter [0.04 inch]) have also been reported (e.g., Smit et al. 2006); however, they are associated with instantaneous burials on benthic species, not gradual smothering impacts.

As described in Section 6.3.3, Impact Assessment—Marine Geology and Sediments, modeling of drill cuttings discharges for eight well/current combination scenarios indicated the maximum depositional thickness of cuttings on the seafloor is predicted to be between 126.7 and 560.8 centimeters (50 and 221 inches), depending on currents, drill center locations, and scenario considered. The model-predicted extent of cuttings deposition above the 5 centimeters (2 inches) per month threshold will be confined to within a relatively short distance from the drill center locations, with the area above 5 centimeters (2 inches) accumulation thickness predicted to be approximately 8,381 m^2 (90,400 ft^2) for the scenario with the greatest modeled maximum thickness. Figure 7.9-17 depicts the maximum total thickness of deposited cuttings for this scenario.

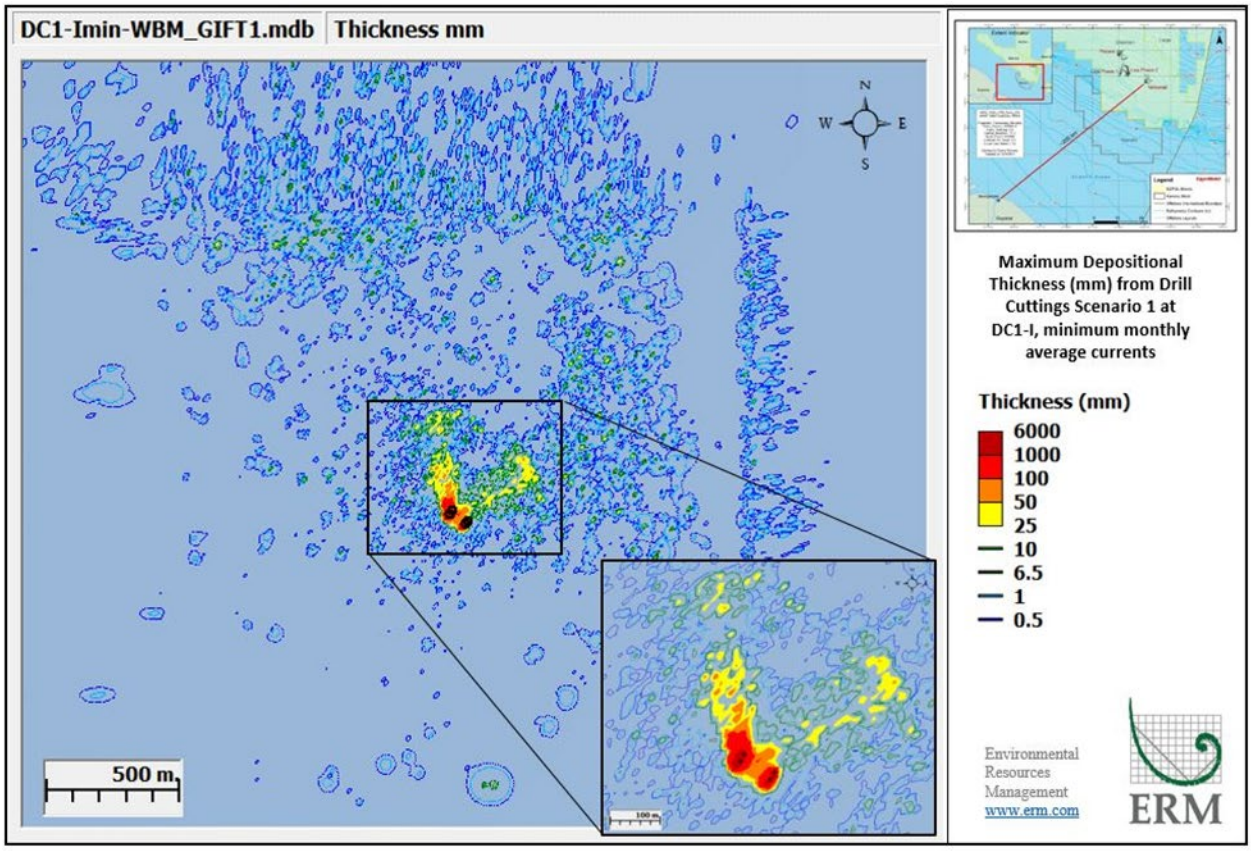


Figure 7.9-17: Accumulated Cuttings based on Model Results

If it is conservatively assumed that up to three drill ships will be active simultaneously on Yellowtail drill centers and all drill ships will undertake drilling that matches the above-referenced scenario, the conservative approach is therefore to triple the affected area results from Table 6.3-6 to reflect the largest area predicted to be subjected to a cuttings deposition rate greater than 5 centimeters (2 inches) per month at any one time. This results in a predicted area of approximately 25,143 m^2 (approximately 270,637 ft^2), which represents approximately 0.07 percent of the area of the Subsea PDA (which itself covers approximately 0.1 percent of the Stabroek Block). Further, the currents are expected to redistribute the cuttings away from their initial deposition sites over time, gradually reducing their thickness on the seafloor at these locations.

With respect to potential impacts from exposure of benthos to toxins in disturbed sediments, the U.S. National Oceanic and Atmospheric Administration (NOAA) has developed numerical sediment quality guidelines (SQGs) as informal (non-regulatory) tools to interpret chemical data from analysis of sediments. As described in Section 6.3.2.3, Marine Sedimentology, sediment samples were collected from eight stations in 2018 as part of the EBS for the Payara PDA (Fugro 2019b). These data were compared to the NOAA SQGs, where available, to assess the possible toxicological significance of chemical concentrations in the sediments. However, the SQGs were derived in units of dry weight sediments and do not account for geochemical factors in sediments that may influence contaminant bioavailability. The comparison does indicate that

a few metals and polycyclic aromatic hydrocarbons (PAHs) are present in the sediments at concentrations that could present a possible threat to organism health.

Specifically, for the 12 metals analyzed and for total PAHs:

- The mean concentration of arsenic (37.8 microgram per gram [µg/g]) exceeded the Effects Range Low[42] (ERL) SQG of 8.2 µg/g, and the maximum concentration (250 µg/g) exceeded the Effects Range Median[43] (ERM) SQG of 70 µg/g.
- The maximum concentration of nickel (26.1 µg/g) exceeded the ERL SQG of 20.9 µg/g, but did not exceed the ERM SQG of 51.6 µg/g.
- Concentrations of cadmium, chromium, copper, mercury, lead, and zinc were all less than the NOAA SQGs.
- Aluminum, barium, iron, and selenium do not have recommended SQGs for comparison.
- Concentrations of total PAHs were nearly three orders-of-magnitude less than the suggested NOAA ERL SQG of 4.022 µg/g and ERM SQG of 44.792 µg/g.

Samples collected from the 2019 and 2020 Hammerhead EBSs also recorded concentrations of arsenic and nickel above the ERL SQGs. These were attributed to natural levels related to the geology and the influence of riverine inputs.

Although chemical information is not available for the specific sub-seafloor strata at the drilling locations, the surficial inorganic sediment chemistry is used for assessing the potential for long-term toxicological impacts on the benthos population as a result of seabed disturbance.

Uncontaminated marine sediments contain from 5 to about 40 milligrams per gram dry weight total arsenic, with higher average concentrations generally found in deep-sea sediments. A review of arsenic in the marine environment (Neff 1997) concluded that arsenic concentrations below the ERL are expected to rarely cause adverse effects on benthic organisms, while concentrations of arsenic in sediments between the ERL and ERM may occasionally cause adverse effects. Further, concentrations of arsenic above the ERM value of 70 milligrams per gram are expected to be associated frequently with adverse effects on benthic organisms.

There are limited chronic nickel toxicity data available for marine sediments and tropical marine species. However, the NOAA Screening Quick Reference Tables (SQuiRTs)[44] provides background levels of metals in marine sediments and presents screening concentrations for nickel and other inorganic analytes in marine sediments that may threaten marine animals. The background SQuiRT value for nickel is 9.9 µg/g (NOAA 2008). Using the same rationale that Neff (1997) applied to arsenic, it is considered that concentrations of nickel in sediments between the ERL and ERM may occasionally cause adverse effects.

[42] The ERL value is the concentration of a potential contaminant at which negative effects are rarely observed.
[43] The ERM value is the concentration of a potential contaminant above which negative effects have been observed in more than 50 percent of the cases studied.
[44] SQuiRT benchmark levels are preliminary screening concentrations for chemicals in various environmental media, in this case marine sediments, which are used to evaluate the potential risks to coastal habitats from sediment that may be contaminated with organic and inorganic compounds.

With respect to potential impacts from exposure of benthos to toxins in the discharged cuttings, embedded controls in the Project design that will reduce the potential impact of drill cuttings discharges on sediment quality include use of International Association of Oil and Gas Producers Group III NADF for bottom-hole sections. Group III NADF includes fluids produced by chemical reactions and highly refined mineral oils that contain levels of total aromatics below 0.5 percent and PAH levels below 0.001 percent (Sanzone et al. 2016). Potential toxicity can be assessed by using the SQGs developed by NOAA (Long et al. 1995) for total PAHs. PAHs are appropriate as a conservative proxy for total hydrocarbons in this case because PAHs are among the most toxic group of petroleum hydrocarbons to marine life (Snyder et al. 2015). Assuming a maximum weight percent of 6.9 NADF on discharged cuttings, as described in Appendix C, Water Quality Modeling Report, the maximum probable concentration of PAHs (assuming a PAH content of 0.001 percent of NADF) in the discharged cuttings would be 0.65 µg/g. This is well below the suggested NOAA ERL SQG of 4.022 µg/g; therefore, PAHs are not expected to be the driver of any ecotoxicological hazard[45]. Deposited cuttings and additional (non-cutting) sediments will gradually mix with and overlay the cuttings over time, gradually returning the surficial sediment layer to a chemical state similar to existing conditions.

With respect to potential impacts from increased TSS concentrations, this effect will pose little risk to most benthos outside the immediate vicinity of the wells. Deposition above the 5 centimeters (2 inches) smothering threshold and TSS concentrations above the 35 milligrams per liter (mg/L) threshold will occur.

Considering the potential sources of impact from drill cuttings discharge above, all of which will extend over only a localized area in the immediate vicinity of the drill centers (i.e., within a portion of the **Direct AOI**), the intensity of impact on marine benthos from drill cuttings discharges is considered **Low**. While there will be periods curing the drilling and installation stage when sediment disturbance and cuttings deposition will not occur, the impact will be present throughout the drilling and installation stage, yielding a **Continuous** frequency rating. The impacts will persist for less than a year in aggregate, but drilling for the Project is expected to occur over multiple years, so the duration is considered **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude of impact on sediment morphology from drill cutting deposition is considered **Small** (see Table 7.9.7).

Table 7.9-7: Magnitude Rating for Potential Impacts on Marine Benthos from Drill Cuttings Discharge

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Drilling and Installation	Marine benthos—injury due to increased TSS concentrations and drill cuttings deposition	Direct AOI	Low	Continuous	Long-term	Small

[45] The percentage of PAH in NADF is used an indicator of overall NADF toxicity because although there are other hydrocarbons in NADF, the toxicity of NADF is generally assessed on the basis of PAH content.

Sensitivity of Receptor—Injury Due to Drill Cuttings Discharge

A study of benthic megafauna in a similar environment offshore Venezuela found that abundances in the vicinity of offshore development sites were significantly reduced after drilling. Highly mobile organisms returned to the area soon after drilling was completed. However, the species composition of immobile taxa was altered, with analyses suggesting that their density increased further away from areas that had been disturbed. The recovery potential of deepsea marine benthic biological resources, particularly immobile taxa, following cessation of drilling activities is unknown (Jones et al. 2012). Immobile individuals will likely experience injury or mortality in areas where drill cuttings deposition exceeds the above-referenced threshold; however, long-term impacts on the benthos population are not expected as a result of smothering of these individuals. Benthic macrofauna, including shrimp and red crabs, are capable of moving rapidly away from impacted areas, so these species will be expected to mostly avoid injury and mortality due to smothering. Giant marine isopods are comparatively less mobile and will therefore be comparatively more sensitive to potential impacts from smothering than crabs and shrimp.

With respect to toxicity impacts, contaminants deposited on the seafloor can pose risks to those deep-sea benthos living within or in close association with bottom substrates that are unable to avoid exposure due to their relatively sedentary existence. These effects would be localized within the immediate vicinity of the cuttings deposition zone. The series of EBS investigations conducted since EEPGL began operations in the Stabroek Block has established a high degree of homogeneity in the benthic community across the block, especially in the soft-bottom communities that characterize the Yellowtail PDA. Consequently, impacts on a portion of the benthic community due to settling of drill cuttings would be unlikely to have significant impacts on species composition or populations across the broader Stabroek Block.

Based on consideration of the above factors, the overall sensitivity of marine benthos to drill cuttings deposition impacts was rated as **Low**.

Impact Significance—Injury Due to Drill Cuttings Discharge

Based on the magnitude of impact and receptor sensitivity ratings, the significance of potential impacts on marine benthos associated with injury from discharge of drill cuttings is considered **Negligible**.

7.9.3.4. Characterization of Impacts—Injury or Disturbance Due to FPSO and SURF Installation

Magnitude of Impact—Injury or Disturbance Due to FPSO and SURF Installation

The shallow sediment layer will be disturbed during installation of subsea infrastructure (SURF and FPSO mooring structures) on the seabed. In addition to disturbance of the habitat, individual benthic organisms are likely to be crushed, dislocated from the substrate (immobile organisms), or dismembered as a result of installation activities. As indicated in Table 7.9-8, which summarizes the area that will be disturbed by installation of various infrastructure components, approximately 66 hectares (approximately 163 acres, incorporating a 50 percent

contingency factor) will be subject to essentially one-time disturbance by the installation activities. The subset of this area occupied by pipelines and flowlines (approximately 36 hectares or 88 acres) will be subject to periodic disturbance for pipeline inspections. The use of anchors by vessels other than the FPSO is not expected; other vessels will use dynamic positioning to maintain a station offshore, so no anchoring-related impacts will occur as a result of the Project apart from the 7.2 hectares (17.7 acres) of seabed disturbance associated with the FPSO.

Table 7.9-8: Area of Benthic Habitat Disturbed by FPSO and SURF Subsea Infrastructure Installation

Equipment	Quantity	Unit Area / Width	Subtotal (m^2)
Trees	67	21 m^2	1,407
Flying leads	15,520 meters	1-meter width	15,520
Production manifolds	6	135 m^2	810
Production flowline structures	22	100 m^2 / 12 meters	2,200
Water alternating gas injection manifolds	6	135 m^2	810
Gas injection distribution manifold	0	135 m^2	0
Water injection pipeline structures	5	100 m^2 / 12 meters	500
Gas injection pipeline structures	6	100 m^2/ 12 meters	600
Gas injection line	21,080 meters	3-meter width	63,240
Production line	39,979 meters	3-meter width	119,937
Umbilical line	27,700 meters	3-meter width	83,100
Water injection line	30,084 meters	3-meter width	90,252
SDU/EDUs mudmats	12	72 m^2	864
UTA only mudmats	9	40 m^2	360
FPSO anchor piles and chains	20	250 m^2	5,000
FPSO mooring leg prelay [a]	20	3,000 m^2	60,000
		Subtotal	444,600
		Total with approximately 50% contingency	666,900

EDU = Electrical Distribution Unit; SDU = Subsea Distribution Unit; UTA = Umbilical Termination Assembly
[a] The mooring legs will be laid on the seafloor prior to arrival of the FPSO, but once the FPSO arrives on station in the PDA, it will be connected to the mooring legs, which will suspend the mooring legs in the water column. Therefore, most of the 60,000 m^2 (16.3 acres) of benthic habitat impacts associated with the mooring legs will be temporary.

Injury or disturbance of marine benthos due to SURF installation will be limited to approximately 2 percent of the Subsea PDA or approximately 0.003 percent of the Stabroek Block. The mortality of benthos, particularly immobile taxa, which are directly contacted during installation of subsea infrastructure within this area, is anticipated to be high. Although some organisms will survive, they may be left with injuries that may impair their survival by making them prone to infection or vulnerable to predators. In addition, the population structure in the specific disturbance areas may temporarily change as more motile benthos taxa enter the disturbed area to scavenge organisms that did not survive. However, the affected area will be so small that the impacts are predicted to be insignificant at the population and ecosystem scales.

Noise and light generated during installation activities could affect the behavior of benthos in the immediate vicinity of the installation activities, but these effects will be limited by the short-term nature of the noise and minimal amounts of light (primarily from ROVs) that will be used at the seafloor. Once the Project enters operation, the only pervasive sound associated with the Project at the sea floor will be from hydraulic fluid moving through valves and oil and gas moving though flowlines to the surface. The use of artificial lights would be limited to the occasional light from ROVs used during inspections. Moreover, many deep-sea benthic taxa that are likely to occur in the PDA (including the sponges, sipunculid worms, nematodes, most mollusks, sea urchins, sea stars, bryzoans, and some annelids) have little to no sense of hearing or eyesight and, as such, would have extremely limited exposure to the temporary introduction of noise and light into their environment during SURF installation.

These impacts will occur within a small portion of the **Direct AOI**. Based on the discussion above, the intensity of impact on marine benthos is considered **Low**. The impact for each portion of the infrastructure will occur on a one-time basis, yielding an **Episodic** frequency rating. The duration for each impact will be **Short-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude of impact on sediment morphology from drill cutting deposition is considered **Negligible** (see Table 7.9-9).

Table 7.9-9: Magnitude Ratings for Potential Impacts on Marine Benthos

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Drilling and Installation	Injury or disturbance due to FPSO and SURF installation	Direct AOI	Low	Episodic	Short-term	Negligible

Sensitivity of Receptor—Injury or Disturbance Due to FPSO and SURF Installation

The sensitivity of the marine benthos population to FPSO and SURF installation impacts is considered **Low**. While the mortality rate of immobile taxa individuals from physical disturbance resulting from installation of the subsea infrastructure will be high, the population is not anticipated to be sensitive to the reduction in individuals within the limited area affected.

Impact Significance—Injury or Disturbance Due to FPSO and SURF Installation

Based on the magnitude of impact and receptor sensitivity ratings, the significance of potential impacts on marine benthos associated with injury or disturbance due to FPSO and SURF installation is considered **Negligible**.

7.9.3.5. Characterization of Impacts—Presence (and Abandonment) of Subsea Infrastructure

Magnitude of Impact—Presence (and Abandonment) of Subsea Infrastructure

As described in Section 2.12, End of Yellowtail Operations (Decommissioning), at the end of operations some subsea infrastructure, including the SURF equipment connected to the FPSO

(e.g., risers, umbilical), SURF equipment sited on the seafloor, and FPSO mooring system, may be disconnected and abandoned in place on the seafloor consistent with the decommissioning plan. This would constitute an irreversible loss of natural, soft, bottom habitat within the collective footprint of these structures, but some species of benthos may colonize this hard substrate or be attracted to it as an artificial reef, as found in shipwrecks in the Gulf of Mexico (Kilgour and Shirley 2008). This will only occur within the immediate footprint of the abandoned infrastructure and is expected to affect a relatively small number of organisms. These positive impacts will be temporary for any infrastructure removed at the time of decommissioning.

The addition of small amounts of hard substrate will likely increase the diversity of the local benthic community as species that require hard substrate colonize the area where none existed before, but this must be balanced with the loss of soft substrate that will continue to be unavailable within the footprint of the subsea infrastructure (Stanley and Wilson 1991). While these effects will occur over a small area of the PDA, the potential net effect on marine benthos is considered **Positive** (see Table 7.9-11).

Sensitivity of Receptor—Presence (and Abandonment) of Subsea Infrastructure

The sensitivity of the marine benthos to this impact is considered **Low**, as only a small number of organisms will be impacted and those are species that are accustomed to colonizing hard substrate, in an area where this type of surface is not common.

Impact Significance—Presence (and Abandonment) of Subsea Infrastructure

Based on the magnitude of impact and receptor sensitivity ratings, the significance of potential impacts on marine benthos from the presence and abandonment of subsea infrastructure is considered **Positive**.

7.9.4. Management Measures—Marine Benthos

Based on the **Negligible** significance of potential marine benthos impacts, no mitigation measures are proposed. Table 7.9-10 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 7.9-10: List of Embedded Controls and Monitoring Measures

Embedded Controls
When NADF is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.
For all vessel effluent discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage), comply with International Maritime Organization / International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 mg/L on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored and the discharge meets the noted specification.

Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C (5.4°F) at 100 meters (approximately 328 feet) from discharge point.
Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals.
Measure residual chlorine concentration of sewage discharges form the FPSO monthly to stay below 0.5 mg/L in accordance with MARPOL 73/78 regulations.
Perform daily visual inspections on the FPSO of discharge points to verify that there are no floating solids or discoloration of the surrounding waters.
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.
Implement chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes: • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.
For effluent released from the onboard sewage treatment plant, comply with aquatic discharge standards in accordance with MARPOL 73/78 regulations.
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter [approximately 1 inch] particle size or less) prior to discharge.
Confirm there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge. Perform daily inspections to verify no visible sheen from discharge of cooling water.
Treat bilge water in accordance with MARPOL 73/78 to comply with an oil-in-water content of less than 15 ppm, as applicable.
Mitigation Measures
Following start-up of production operations, implement a program to characterize effluent water discharges from the FPSO and conduct an environmental risk assessment based on the characterization data. As appropriate based on the results of the environmental risk assessment, implement additional treatment options, if warranted and feasible.
Monitoring Measures
Prior to and post-drilling, an ROV will take pictures of the area immediately surrounding the well location to monitor for marine water quality impacts.
Monitor daily during drilling to confirm that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NABF will not exceed 6.9 percent wet weight base fluid retained on cuttings.
Monitor daily produced water discharge volume.
Measure oil and grease content of produced water (grab sample once per day).
Perform daily inspections to verify no visible sheen from discharge of cooling water.
Monitor discharge temperature of cooling water and produced water to avoid increases in ambient water temperature of more than 3°C (5.4°F) at 100 meters (~328 feet) from point of discharge.
Utilize load-monitoring system in the FPSO control room to support FPSO offloading.
Monitor pressure and temperature of subsea wells and manifolds by a control system on the FPSO to detect and prevent leaks.
Monitor chlorine concentration of treated sewage discharges.

Perform daily visual inspection of discharge points to verify absence of floating solids or discoloration of the surrounding waters.
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book.
Perform oil in water content (automatic) monitoring of bilge water to comply with 15 ppm MARPOL 73/78 limit and record in Oil Record Book.
Record estimated volume of ballast water discharged and location (per ballasting operation).

Table 7.9-11 summarizes the assessment of potential pre-mitigation and residual Project impacts on marine benthos. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment.

Table 7.9-11: Summary of Potential Pre-Mitigation and Residual Impacts—Marine Benthos

Stage	Potential Impact	Magnitude Rating	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Well Drilling	Smothering from deposition, filter fouling from elevated TSS concentrations, and/or toxicity impacts	Small	Low	Negligible	None	Negligible
SURF/FPSO Installation	Injury or disturbance	Negligible	Low	Negligible	None	Negligible
Production Operations Decommissioning	Creation of artificial substrate	Not Rated (Positive)	Low	Positive	None	Positive

7.10. ECOLOGICAL BALANCE AND ECOSYSTEMS

7.10.1. Administrative Framework—Ecological Balance and Ecosystems

Table 7.10-1 summarizes the legislation, policies, or treaty commitments that are specifically relevant to the assessment of potential impacts on ecological balance and ecosystems.

Table 7.10-1: Legislation, Policies, or Treaty Commitments—Ecological Balance and Ecosystems

Title	Objective	Relevance to the Project
Legislation		
Wildlife Management and Conservation Act, 2016 (replaces the Wildlife Management and Conservation Regulations, 2013; the Wild Birds Protection Act, 1987; and the Species Protection Regulations, 1999)	Provides for the protection, conservation, management, sustainable use, internal and external trade of Guyana's wildlife, and establishes and incorporates the Guyana Wildlife Conservation and Management Commission.	Provides a framework to address the national goals for wildlife protection, conservation, and management. The Act also provides recommendations on measures for the protection of threatened ecosystems and habitats, and advises on measures for conservation of biological diversity.
International Agreements Signed/Acceded by Guyana		
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (Guyana acceded and ratified in 2010)	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection for the marine environment, especially from possible pollution. Guyana acceded and ratified in 2010.
Convention on Biological Diversity (Guyana signed in 1992 and ratified in 1994)	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Encourages Project design and execution so as to protect and conserve biological diversity.
Protocol on Specially Protected Areas and Wildlife (Guyana acceded and ratified in 2010)	Protocol supplementing and supporting the Cartagena Convention. Requires signatories to adopt an ecosystem approach to conservation. Provides mechanism for compliance with the Convention on Biological Diversity.	Elaborates on the wildlife goals established in the Cartagena Convention and Convention on Biological Diversity. This protocol relates to efforts to legally recognize and preserve intact ecosystems by Guyana, giving special importance to large areas needed to maintain ecosystem function and balance, including the SBPA.

Title	Objective	Relevance to the Project
International Convention for the Prevention of Pollution from Ships,1973, as modified by the Protocol of 1978 (MARPOL 73/78) (Guyana acceded in 1997)	Regulates various forms of marine pollution, including oil and fuel, noxious liquid, hazardous substances, sewage, garbage, air emissions, and ballast water.	Impacts the handling and disposition of regulated substances from Project drill ships, FPSO, and support vessels. Release of pollution from ships can change and/or compromise the functioning of ecosystems, potentially having implications for altering ecosystem services.

7.10.2. Existing Conditions—Ecological Balance and Ecosystems

In cooperation with the University of Rhode Island, NOAA developed the Large Marine Ecosystem (LME) concept as a model to assess and manage ecological functions at the regional scale. LMEs are defined as relatively large areas of ocean space of approximately 200,000 square kilometers (20,000,000 hectares) or greater. These areas are adjacent to continents in coastal waters where primary productivity is generally higher than in open ocean areas. The PDA is located in the northwestern portion of the North Brazil Shelf LME, which comprises the coastal waters adjacent to northeastern South America from the eastern edge of the Caribbean Sea to the Parnaiba River in Brazil (see Figure 7.10-1). Its width varies, but it extends roughly 500 kilometers (approximately 300 miles) off the coast of Guyana (Marineregions.org 2019).

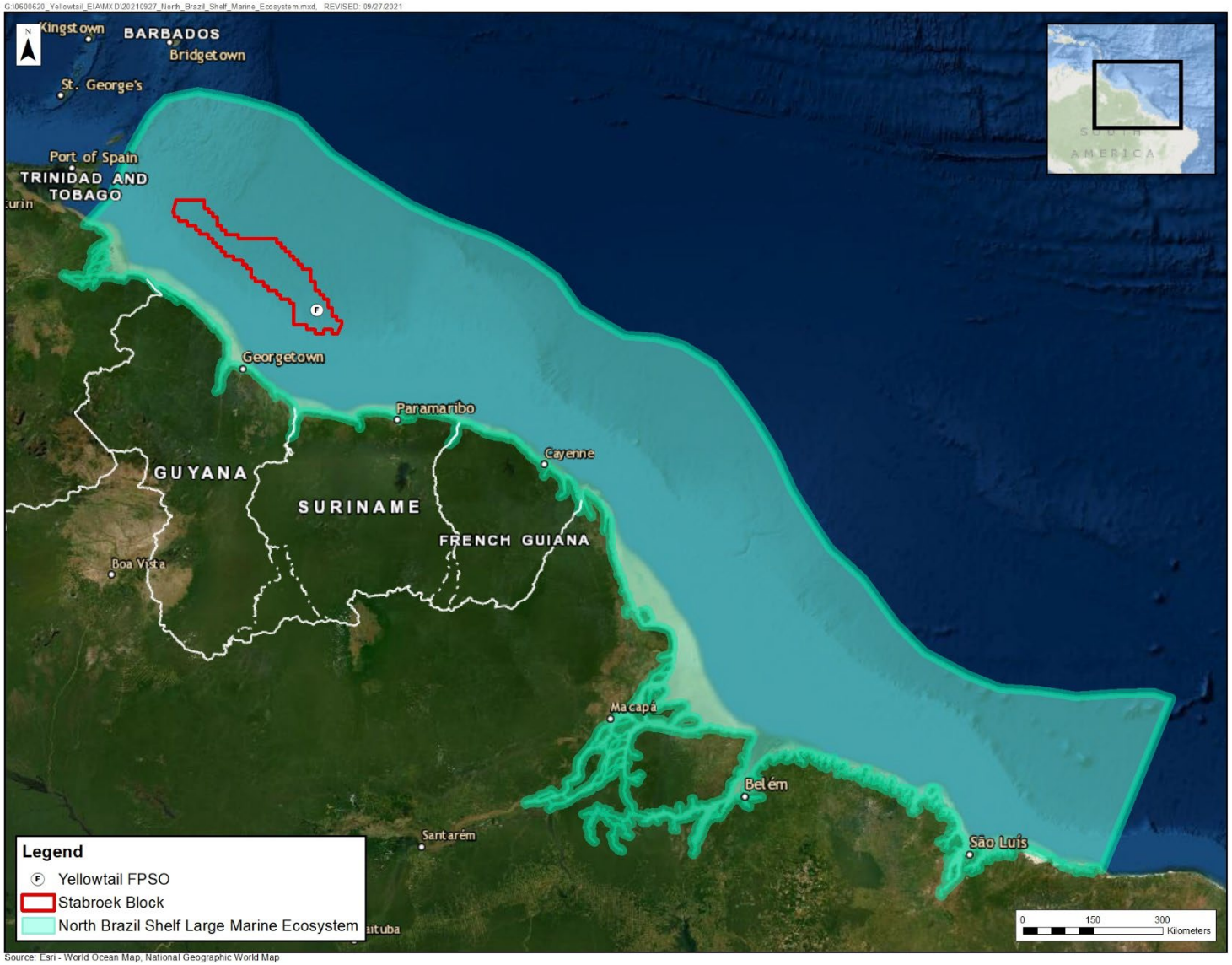


Figure 7.10-1: The North Brazil Shelf Large Marine Ecosystem

The Project is also within the Amazonian-Orinoco Influence Zone, an EBSA that encompasses the offshore waters of eastern Trinidad, Guyana, Suriname, French Guiana, and northern Brazil, and borders the shoreline from the Orinoco River in the north to the Amazon River in the south (Secretariat of the Convention on Biological Diversity 2014). EBSAs are identified on the basis of the following seven criteria: (1) uniqueness or rarity; (2) special importance for life history stages of species; (3) importance for threatened, endangered, or declining species and/or habitats; (4) vulnerability, fragility, sensitivity, or slow recovery; (5) biological productivity; (6) biological diversity; and (7) naturalness. According to the Secretariat, which designated the Amazonian-Orinoco Influence Zone in 2014, the zone's uniqueness and biological productivity are driven largely by the influence of freshwater inputs from the Amazon River and the nutrients it carries, which extend north and west across the coast of northern South America to the Orinoco River delta in Venezuela via the Guiana Current. As described in Sections 7.3, Coastal Wildlife; 7.5, Marine Mammals; 7.7, Marine Turtles; and 7.8, Marine Fish; the Amazonian-Orinoco Influence Zone is important for specific life history stages of several species (several of which are special status species) including colonial seabirds, marine mammals, marine turtles, and fish. Plankton plays an important role in the functioning of marine ecosystems serving at the base of the pelagic food web (Roemmich and McGowan 1995). Planktonic organisms have a direct link with fish (even if this link may only exist during the relatively short period when pelagic fish are mainly planktivorous) because they represent a major source of energy (Cushing 1997, in Beaugrand 2005).

The plankton community is also highly influenced by hydro-climatic forces such as currents, temperature, solar radiation, and bioavailability of marine nutrients, so it is the first trophic[46] level at which physical oceanographic and climatic factors are integrated into the pelagic food web.

An EEPGL-commissioned survey of ichthyoplankton[47] in nearshore and offshore waters of the Indirect AOI in 2018 and 2019 (Appendix M, Nearshore and Offshore Fisheries Study Summary) revealed that the region provides valuable habitat for various early life stages of fish. Results of this survey are summarized in Section 7.8, Marine Fish. Some representative larval fishes from the survey are depicted on Figure 7.10-2.

[46] Relating to a specific rank or position in the food chain
[47] Ichthyoplankton are the eggs and larvae of fish.

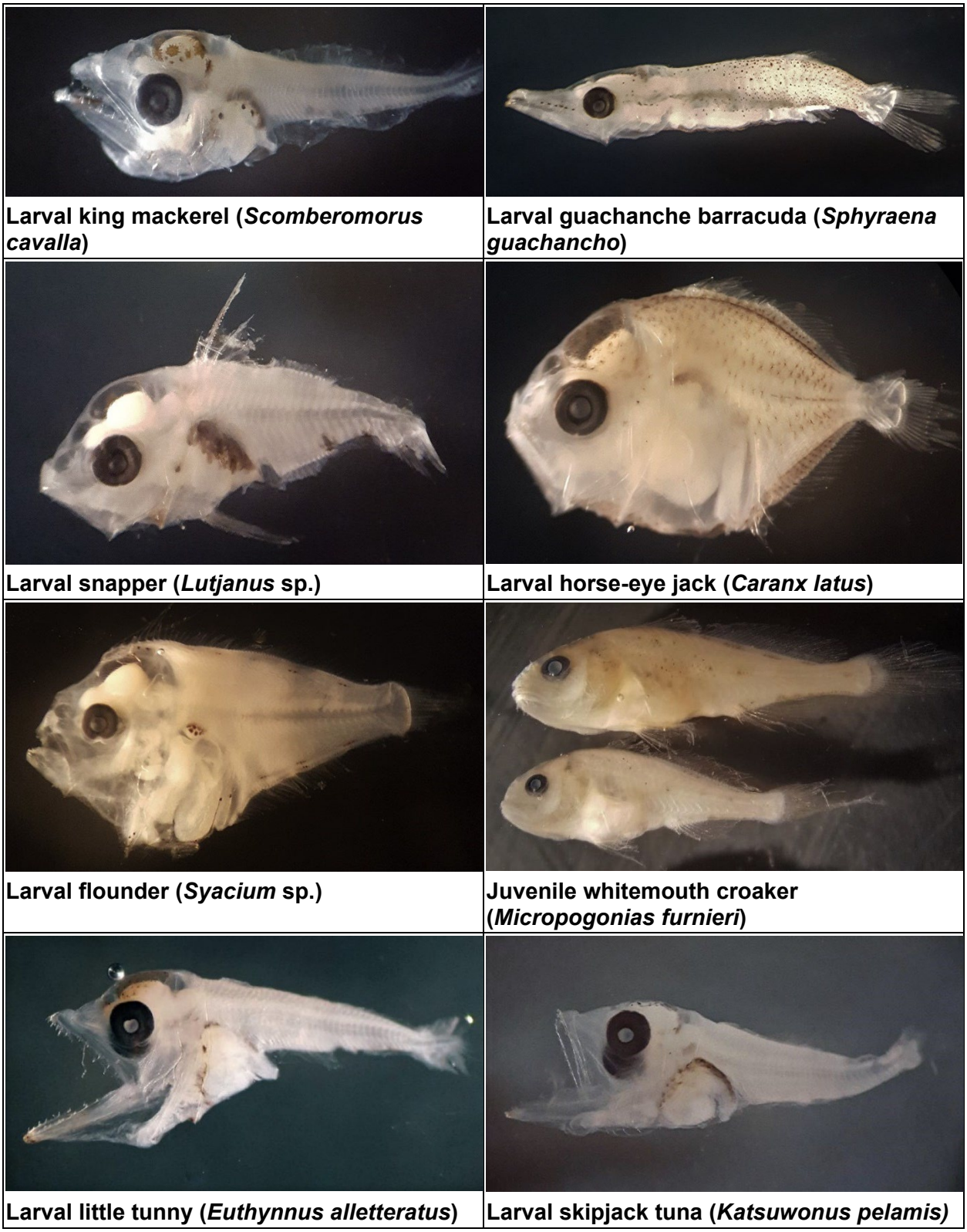


Figure 7.10-2: Representative Species of Ichthyoplankton from the Indirect AOI

There were slightly more marine organisms collected at the nearshore sample stations than at the offshore stations, although taxa richness was higher at the offshore stations. The offshore stations were also more homogeneous in terms of the number of taxa at each station, as compared to the nearshore stations. It is not known whether these apparent differences between the offshore and nearshore stations represent a seasonal or permanent phenomenon, but as described in Section 6.4, Marine Water Quality, the Guiana Current is known to move seasonally, oscillating between offshore and inshore alignments, and intermittently producing eddies and loop currents that separate from the main current. Off Brazil, researchers have reported that the greatest concentration of larvae varied from nearshore to offshore depending on the season, and temperature can also play a major role in plankton distribution. In light of the dynamic nature of the Guiana Current and the influence that macro-oceanographic factors have on plankton distribution, it is likely that the abundance and distribution of plankton across the North Brazil LME (including both the Direct and Indirect AOIs) varies over time. This expected variability notwithstanding, the limited data available indicate that Guyana's marine ichthyoplankton community is similar to that of other nearby regions (e.g., Brazil; de Macedo-Soares et al. 2014) in terms of relative abundance, but possibly more diverse in terms of the number of taxa than other regions within the western Atlantic basin such as the Gulf of Mexico (Ditty 1986; Espinosa-Fuentes et al. 2013).

7.10.2.1. Marine Nutrient Cycle

The three most important nutrients in the marine nutrient cycle are nitrogen, phosphorous, and silicon (Nihoul and Chen 2008). The primary source of all of these nutrients in the marine food web is phytoplankton, which assimilate the nutrients from the surrounding seawater. Nitrogen and phosphorous are essential nutrients to all plant life, and silicates enter the marine nutrient cycle largely through diatoms, a specific class of phytoplankton that construct hard silicate exoskeletons. Each of the world's LMEs has its own rate of biological productivity, which is influenced by bathymetric, hydrographic, and other physical conditions that distinguish it from adjacent LMEs (NOAA 2021). The 66 LMEs that have been delineated are placed in one of five productivity categories, from Very Low to Very High. The North Brazil Shelf LME is in the Highly Productive category (indicating more than 300 grams of carbon produced per square meter of ocean surface per year) and daily primary productivity rates can occasionally exceed 8 grams of carbon per square meter of ocean surface per year in the LME, owing to large nutrient inputs from the Amazon Basin via the Guiana Current as well as complementary inputs from smaller rivers that drain the Guiana Shield (Heileman 2009). High turbidity, particularly near the coast in waters directly influenced by these rivers, is both a function of the high nutrient load and a control on the primary production that these nutrients promote. As such, primary productivity has been found to be highest in the transition zone between nutrient-rich coastal waters with low sunlight transmission and clearer offshore waters where light is transmitted more readily but nutrients are comparatively scarcer (Heileman 2009).

7.10.2.2. Gene Flow

Marine environments (particularly open-ocean environments such as the Stabroek Block) are often considered homogenous across large geographical distances. Consistent with this view, several studies have shown significantly lower genetic differentiation among populations of marine fish species as compared to freshwater fishes. Based on observed rates of genetic differentiation between generations, genetic exchange between marine fish populations has been estimated to occur at 10 to 100 times the rate of exchange in freshwater populations (Ward et al. 1994). Nevertheless, since the late 1990s, studies have increasingly documented genetic differentiation among populations of marine organisms. Genetic boundaries between populations tend to occur along geomorphic and current boundaries (Ruzzante et al. 1998; Nielsen et al. 2003; Johannesson and Andre 2006). Genetic exchange across large expanses of open ocean is aided by the prevalence of planktonic early life stages in numerous taxa.

Several studies of marine biota have been conducted within or in the vicinity of the PDA in recent years, including studies of marine mammals, turtles, fish, and benthos, and none have detected the presence of endemic species. In 2016, environmental DNA was collected from sediment and seawater samples during a baseline survey of the Liza-1 Field. No regionally endemic species were reported. These results are consistent with the concept that genetic isolation is much rarer in the open ocean than on land (CEGA 2016).

7.10.2.3. Biodiversity

Although the marine LME concept was initially based on primary productivity, one of the most readily apparent characteristics of a marine LME is the biodiversity it contains. Detailed information on the biodiversity aspects of the Stabroek Block is provided in Section 7.4.2, Existing Conditions—Seabirds; Section 7.5.2, Existing Conditions—Marine Mammals; Section 7.7.2, Existing Conditions—Marine Turtles; Section 7.8.2, Existing Conditions—Marine Fish; and Section 7.9.2, Existing Conditions—Marine Benthos.

7.10.2.4. Carbon Storage

The deep ocean ecosystem plays a major role in climate regulation, as it is one of the world's major carbon storage systems (also referred to as a carbon sink). The Intergovernmental Panel on Climate Change has estimated that the ocean contains 50 times more carbon than the atmosphere (IPCC 2014). The ocean absorbs carbon dioxide from the atmosphere through numerous chemical, physical, and biological processes, often collectively referred to as the ocean carbon pump, which moves carbon from at or near the ocean surface to the seafloor. The ocean carbon pump has a biological component, which transfers surface carbon and dissolved carbon in upper surface waters toward the seafloor via the food web, and a physical component, which transports dissolved carbon through ocean circulation. The sinking carbon is an important part of the marine food web, as it serves as a food source for many marine organisms. Carbon that reaches the seafloor is consumed by benthic organisms or buried by natural sedimentation processes that sequester the carbon for thousands to millions of years (Xiao et al. 2010).

7.10.2.5. Waste Absorption

The marine ecosystem also provides important waste absorption and assimilation functions, as many biological, chemical, and physical waste products that are generated by people are directly or indirectly disposed of in the ocean and natural marine processes consume, and in some cases degrade or detoxify, a substantial amount of waste products in the ocean through biotic and abiotic processes. These processes break down wastes into their basic components that can be recycled by marine organisms and/or the waste components sink to the seafloor and are buried by sediments, effectively removing them from circulation within the marine ecosystem (Watson et al. 2016).

7.10.3. Impact Assessment—Ecological Balance and Ecosystems

This section addresses the potential impacts of planned Project activities on ecological balance and ecosystems. Although there is no universally accepted definition of key ecological functions (in generic terms or with respect to the North Brazil Shelf LME), they generally include such basic processes as nutrient cycling, gene flow, and maintenance of biodiversity. Therefore, these ecological processes were identified as potential ecological/ecosystem receptors of relevance to this impact assessment. Deep sea ecosystem functions described above, including carbon storage and waste absorption, operate at the global scale and would not be expected to be significantly impacted by planned Project activities; as such, these functions are not discussed further in this impact assessment.

7.10.3.1. Relevant Project Activities and Potential Impacts

The Project's potential ecosystem-level impacts are indirect impacts that will potentially occur as a result of direct impacts on specific abiotic and biotic components of the larger ecosystem. All planned Project activities that could affect the physical or biological attributes of the Project AOI are broadly relevant to an assessment of impacts on ecological balance and ecosystems because their associated potential impacts will occur within the North Brazil LME. Therefore, rather than focusing on individual Project activities and their separate impacts on specific ecosystem components, this section identifies key ecosystem components and functions, and assesses the ecosystem-level implications of the potential impacts identified in the resource-specific impact assessments discussed in prior sections of Chapter 6 and Chapter 7, Assessment of Potential Impacts from Planned Activities—Physical and Biological Resources, respectively, that could potentially impact those key components and functions.

Many of the embedded controls identified in Section 2.14, Embedded Controls, will serve to reduce the magnitude of potential impacts on one or more physical, biological, or chemical attributes of the ecosystem, and will therefore play a role in reducing the initial magnitude of potential impacts on ecological balance and ecosystems. On the basis of the definitions described above and the embedded controls described in other relevant sections of the EIA, the magnitudes of the various potential impacts on ecological balance and ecosystems are discussed below.

7.10.3.2. Magnitude of Impact—Ecological Balance and Ecosystems

The assessment of the Project's magnitude of potential impacts on ecological balance and ecosystems from planned Project activities is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on ecological balance and ecosystems is defined according to the definitions provided in Table 7.10-2. The following paragraphs discuss the characteristics of each of the potential impacts assessed and the resultant magnitude ratings. These are summarized in Table 7.10-3.

Table 7.10-2: Definitions for Intensity Ratings for Potential Impacts on Ecological Balance and Ecosystems

Criterion	Definition
Intensity	Negligible: No measurable ecosystem-level changes.
	Low: Changes are perceptible but affect only a small number of species within the ecosystem, and only at one trophic level.
	Medium: Changes are perceptible and affect many species within the ecosystem, at more than one trophic level.
	High: Changes affect numerous species throughout the food web, such that the basic trophic and biodiversity characteristics of the ecosystem are irrevocably altered.

Changes in the Marine Nutrient Cycle

The Project could potentially indirectly impact the marine nutrient cycle through its impacts on marine water quality, which could impact phytoplankton growth and in turn induce further impacts through the marine food web. As discussed in Section 6.4.3, Impact Assessment—Marine Water Quality, planned activities of the Project are predicted to have negligible impacts on water quality, and these potential impacts are predicted to be limited to a relatively small, localized mixing zone around the FPSO and other Project vessels with routine discharges (these will have even smaller zones of influence compared to that of the FPSO). These potential localized impacts are likely to change the species composition of the phytoplankton community to species (in the case of FPSO-related impacts) tolerant of elevated water temperatures, and this may increase rates of photosynthesis within the mixing zone; however, based on the negligible significance of potential marine water quality impacts, and the very small portion of the North Brazil Shelf LME that will be exposed to these potential impacts, the Project is predicted to have little if any measurable ecosystem-level impacts on nutrient cycling. On this basis, the intensity of impacts on the marine nutrient cycle is considered **Negligible** during all Project stages. These impacts will occur on an essentially continuous basis in the PDA during their respective stages of activity, so the frequency of this impact is considered **Continuous** for all Project stages. The impacts associated with the FPSO will occur over the entire operational life of the Project (at least 20 years) and impacts associated with other vessels will all be greater than a year, so the duration of the impact for all stages is considered **Long-term**. Following the methodology in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude of this impact is rated as **Negligible.**

Impacts on Gene Flow

Maintaining gene flow is critical to supporting the genetic diversity in marine biological populations, which in turn is an important factor in the general resilience and vigor of marine flora and fauna. Obstacles to efficient gene flow occur whenever physiochemical barriers to migration, breeding, or dispersal/colonization occur. Oceanic currents are a key driver of biological dispersal because many marine species spend all or part of their lives drifting as part of the plankton. Site-specific reproductive events (such as spawning aggregations or migrations) occur at locations where a specific combination of physio-chemical conditions is uniquely favorable to support them. A project could potentially have significant impacts on gene flow if it impacts large-scale current patterns, alters the geological boundaries of ocean basins, or prevents site-specific reproductive events (such as spawning aggregations) from occurring by altering the physio-chemical conditions on which they depend. The Project is not predicted to have any appreciable impact on regional current patterns that define the North Brazil Shelf LME, nor is it predicted to impact any site-specific reproductive activities that could be considered significant at a regional or ecosystem scale. As described in various sections in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources, the effects of the Project on physical and chemical oceanographic parameters are expected to diminish to near-background conditions within a few hundred meters of the FPSO. Furthermore, no spawning aggregations, migration pathways, or other unique reproduction-related habitat features are known to occur within this zone, so the Project would not be expected to affect site-specific reproductive activity. On this basis, the intensity of impacts on the marine nutrient cycle is considered **Negligible** for all Project stages. These impacts will occur on an essentially continuous basis in the PDA during their respective stages of activity, so the frequency of this impact is considered **Continuous** for all Project stages. These impacts will occur over the entire life of the Project (at least 20 years), so the duration of the impact for all stages is considered **Long-term**. Following the methodology in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude of this impact is rated as **Negligible.**

Impacts on Biodiversity

The Project is predicted to have numerous potential impacts of varying levels of significance on marine species, but is not expected to impact large-scale distribution of species or cause the loss of any species from within the North Brazil Shelf LME. Some benthic species may be locally displaced from the footprint of the FPSO and SURF seabed components and some pelagic species may be locally displaced from the surface mixing zone that will form around the FPSO liquid effluent discharges, but these potential impacts will be insignificant at the ecosystem scale. Additionally, there is no reasonable potential for the Project to cause the extinction or extirpation of any species from the North Brazil Shelf LME, or to measurably exacerbate any of the risk factors that have contributed to the listing of the special status species assessed in Section 7.1.3, Impact Assessment—Protected Areas and Special Status Species.

The greatest potential for affecting biodiversity in the LME is associated with the potential introduction of exotic species from ballast exchanges by export tankers visiting the LME during

production operations. The global movement of ballast water is considered to be the largest transfer mechanism for marine non-indigenous species (Ruiz et al. 2005). Ballast water is water carried in ships' ballast tanks to improve vessel stability, balance, and trim; it is essential for the safe operations of oceangoing ships. It is taken onboard or discharged when cargo is unloaded or loaded, or when a ship needs extra stability in foul weather. When ships take on ballast water, aquatic plants and animals may also be entrained into the ballast tanks. These organisms are transported in the ballast tanks of the ships; upon being discharged, some non-native species may survive and establish themselves in the new environment if the habitat conditions are suitable. If the non-native species become invasive, they may result in ecological, economic, and public health impacts (MCA 2008). If the invasive species become dominant in the new environment, they can displace native species, change local/regional biodiversity, and affect local economies based on fisheries (NOAA Fisheries Undated).

The Caribbean Invasive Alien Species Working Group, of which Guyana is a member, has identified one species, the green mussel (*Perna virdis*), as having been introduced to the Caribbean and South American coastal waters via ballast water (Caribbean Invasives.org 2021).

Three types of ballast exchanges will occur at different Project stages:

- Ballast water exchanges by the FPSO while en route to the PDA;
- Recurring intake/discharges of ballast water by the FPSO as it alternately transfers crude oil to market and takes on new crude oil from the reservoirs, respectively; and
- Recurring discharges of ballast water by export tankers as they take on crude oil from the FPSO.

The first ballast water exchange will replace water taken on at the FPSO's point of origin with water from deep international waters (prior to arrival in Guyanese waters). The second ballast exchange will discharge ballast water taken on in the first exchange with water from just outside the Guyana EEZ, immediately before the FPSO enters Guyanese waters. Exchanges of the FPSO's ballast water while en route to the PDA will take place as an embedded control to reduce the potential impact of invasive species introduction. This practice is generally thought to reduce the likelihood of introducing invasive species to new coastal habitats because oceanic organisms are considered unlikely to colonize coastal habitats (Ruiz et al. 2005). This rationale is based on an assumption that coastal waters (where most ports are located) are sufficiently different from the open ocean in terms of salinity and physical habitat conditions such that most organisms from the coast will not be able to survive and colonize the open ocean, and vice versa.

The second type of ballast exchange described above will discharge ballast water taken onto the FPSO within the PDA back to the PDA in the same location it was taken onboard. This process will occur throughout the Project's operational stage, on a continual basis. It will pose no risk of introduction of non-native species because the water will be discharged at its point of origin.

The third type of ballast exchange described above will discharge ballast water taken onboard at numerous, unidentified high seas locations by export tankers to the PDA. It is estimated that a maximum of 629,000 barrels (100,000 cubic meters) of ballast water (Table 6.4-8) will be discharged during each loading event. These ballast water discharges will be conducted in accordance with internationally recognized standards and in compliance with International Maritime Organization (IMO) requirements[48]. The ecological effect will be similar to the effect of the initial ballast discharge from the FPSO in the sense that organisms from the open ocean could be discharged by the exports tankers upon arrival in the PDA.[49] The environmental conditions at the offshore point where coastal ballast water is exchanged for oceanic water (either by the FPSO during its initial voyage to the PDA or by market tankers approaching the FPSO once it is operational) will likely be somewhat similar to the conditions in the PDA. Using the same logic explained above for the initial FPSO discharge, some organisms entrained in deeper oceanic waters and then discharged into the PDA will likely survive the event; however, these organisms will likely include many of the same open-ocean species that occur naturally in the PDA.

As described in Section 7.10.2, Existing Conditions—Ecological Balance and Ecosystems, the Guiana Current heavily influences oceanographic and biological conditions offshore northeast South America and can be considered the defining characteristic of the North Brazil LME. The Guiana Current extends north and west along the coast of northern South America from the Amazon River delta past the Project to the Orinoco River delta in Venezuela. The Project will not change any of the fundamental hydrological characteristics of the Amazon River or the macro-scale oceanographic characteristics of the eastern North Brazil LME, which drive the Guiana Current at the Project site. The volume of the aqueous discharges from the Project will be insignificant compared to the volume of the Guiana Current as it flows past the Project, so the Project is not expected to significantly influence the oceanographic environment west of the Project within the North Brazil LME (or the Guiana Current's effects on this area). Based on the scale of the planned discharges relative to the Guiana Current's influence on biophysical oceanographic conditions in the AOI, the intensity of impacts on biodiversity from ballasting operations is considered **Low**. The potential for an invasive species introduction occurring will persist over the life of the Project and could affect an area beyond the PDA and into portions of the **Indirect AOI**; however, based on the expectation that such an introduction would be infrequent, the frequency is considered **Episodic** in nature. In the event that an introduction does occur and the introduced species becomes established, the associated impacts will occur over the entire operational stage of the Project and potentially beyond (at least 20 years), so the duration of the impact for this stage is considered **Long-term**. Following the methodology in

[48] This conclusion is based on an assumption that export tankers will comply with applicable IMO requirements; however, EEPGL will have no role in enforcing compliance with these requirements.

[49] Guyana ratified the IMO's Ballast Water Management Treaty in 2019, which requires all vessels (including those flagged by non-signatory nations and calling on ports in signatory nations' territorial waters) to exchange ballast water at least 200 nautical miles (370.4 kilometers) from land. Therefore, the same embedded controls described above for the initial FPSO ballast water exchange will effectively apply to all export tankers entering the PDA, regardless of the tankers' flag status.

Chapter 4, Methodology for Preparing the Environmental Impact Assessment, the magnitude of this impact is rated as **Small.**

Table 7.10-3: Magnitude of Impact—Ecological Balance and Ecosystems

Stage	Receptor- Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
All Project Stages	Changes in marine nutrient cycle, resulting in localized and temporary changes in phytoplankton species distribution	Direct AOI	Negligible	Continuous	Long-term	Negligible
	Impacts on gene flow	Direct AOI	Negligible	Continuous	Long-term	Negligible
	Introduction of invasive species via ballast water	Indirect AOI	Low	Episodic	Long-term	Small

7.10.3.3. Sensitivity of Receptor—Ecological Balance and Ecosystems

The assessment of the ecosystem as a broad receptor of indirect impacts from the Project is based on the sensitivity of the receptor to the initial direct impact that will drive the ecosystem-level impacts. Ecosystem level sensitivity is defined according to the definitions provided in Table 7.10-4.

Table 7.10-4: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Ecological Balance and Ecosystems

Criterion	Definition
Sensitivity	Negligible: Biological impacts affect receptors with no specific value or importance attached to them.
	Low: Biological impacts affect species and sub-species of Least Concern on the IUCN Red List (or not meeting criteria for medium or high value), or without specific anatomical, behavioral, or ecological susceptibilities to Project-related impacts.
	Medium: Biological impacts affect species listed as Vulnerable, Near Threatened, or Data Deficient on the IUCN Red List, species protected under national legislation, nationally restricted range species, nationally important numbers of migratory or congregatory species, species not meeting criteria for high value, and species vital to the survival of a medium value species.
	High: Biological impacts affect species on IUCN Red List as Critically Endangered or Endangered. Species having a globally restricted range (e.g., fauna having a distribution range less than 50,000 square kilometers (19,305 square miles), internationally important numbers of migratory, or congregatory species, key evolutionary species, and species vital to the survival of high value species.

Based on the sensitivity rating definitions above, the receptor sensitivity for the ecosystem is considered **Low** for impacts on nutrient cycling and gene flow, and **Medium** for impacts on biodiversity. The ratings for nutrient cycling and gene flow are principally due to the assimilative capacity of the LME afforded by its large size, and the assumption that genetic exchange

between the North Brazil LME and adjacent LMEs is robust due to the general lack of obstacles to gene flow in the ocean. The sensitivity rating for impacts on biodiversity is principally due to the numerous species in the LME that are listed as Data Deficient by the IUCN, and the fact that the plankton community (which forms the basis of the marine food web) will likely be the first element of the ecosystem to be impacted by introduction of non-indigenous species.

7.10.3.4. Impact Significance—Ecological Balance and Ecosystems

Based on the magnitude of impact and receptor sensitivity ratings described above, the pre-mitigation significance ratings for potential impacts on ecological balance and ecosystems ranges from **Negligible** to **Minor**.

7.10.4. Management Measures—Ecological Balance and Ecosystems

The embedded controls integrated into the Project design and operational procedures constitute the practicable measures that are available to reduce the significance of potential impacts on ecological balance and ecosystems. Table 7.10-5 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 7.10-5: List of Embedded Controls and Monitoring Measures

Embedded Controls
For all vessel effluent discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage), comply with IMO / International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Limit oil content of discharged produced water to 42 mg/L on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored, and the discharge meets the noted specification.
Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C (5.4˚F) at 100 meters (approximately 328 feet) from discharge point.
Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals.
Abide with IMO (2004) guidelines including the International Convention for the Control and Management of Ship's Ballast Water and Sediments, with the exception of Regulation D-2 (Ballast Water Performance Standard) while the FPSO is on station, and abide with MARPOL 73/78.
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.
Mitigation Measures
Following start-up of production operations, implement a program to characterize effluent water discharges from the FPSO and conduct an environmental risk assessment based on the characterization data. As appropriate based on the results of the environmental risk assessment, implement additional treatment options, if warranted and feasible.
Monitoring Measures
Measure residual chlorine concentration of sewage discharges form the FPSO monthly to verify it is below 0.5 mg/L in accordance with MARPOL 73/78 regulations.
Perform daily visual inspections on the FPSO of discharge points to verify that there are no floating solids or discoloration of the surrounding waters.

Monitor daily during drilling to confirm that end of well maximum weighted mass ratio averaged over all well sections drilled using NABF shall not exceed 6.9 percent wet weight base fluid retained on cuttings.
Monitor daily produced water discharge volume.
Measure oil and grease content of produced water (grab sample once per day).
Perform daily inspections to verify no visible sheen from discharge of cooling water.
Monitor discharge temperature of cooling water and produced water to avoid increases in ambient water temperature of more than 3°C (5.4°F) at 100 meters (approximately 328 feet) from point of discharge.
Use load-monitoring system in the FPSO control room to support FPSO offloading.
Monitor pressure and temperature of subsea wells and manifolds by a control system on the FPSO to detect and prevent leaks.
Perform daily visual inspection of discharge points to verify absence of floating solids or discoloration of the surrounding waters.
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book.
Perform oil in water content (automatic) monitoring of bilge water to comply with 15 ppm MARPOL 73/78 limit and record in Oil Record Book.
Record estimated volume of ballast water discharged and location (per ballasting operation).

Table 7.10-6 summarizes the assessment of potential pre-mitigation and residual Project impacts on ecological balance and ecosystems. The significance of impacts was rated based on the impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, and the resource-specific methodology described above.

Table 7.10-6: Summary of Potential Pre-Mitigation and Residual Impacts—Ecological Balance and Ecosystems

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project Stages	Changes in marine nutrient cycle, resulting in localized and temporary changes in phytoplankton species distribution	Low	Negligible	Negligible	None	Negligible
	Impacts on gene flow	Low	Negligible	Negligible	None	Negligible
	Introduction of invasive species via ballast water	Medium	Small	Minor	None	Minor

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8. ASSESSMENT AND MITIGATION OF POTENTIAL IMPACTS FROM PLANNED ACTIVITIES—SOCIOECONOMIC RESOURCES

For the purposes of this EIA, “socioeconomic environment” is intended to encompass the human aspects of the affected environment, with specific emphasis on the social and economic characteristics of society that could be affected by the Project. Within this chapter, the discussion of existing conditions is based on a combination of primary and secondary information. Primary socioeconomic information includes data obtained directly through community-based studies, surveys, and/or interviews with members of national, regional, and local governments; civil societies and non-governmental organizations (NGOs); local community members; and other Project stakeholders. Secondary data sources include Project-related materials, census data, socioeconomic reports (e.g., academic reports, government reports), and other relevant data received from public sources.

This chapter identifies and assesses the potential impacts on the existing socioeconomic environment in the Project Area of Influence (AOI), including community health and cultural heritage, as a result of Project-related activities. The methods used to assess socioeconomic impacts build upon the general assessment methodology outlined in Chapter 4, Methodology for Preparing the Environmental Impact Assessment. This general approach and methodology have been adapted for use in evaluating impacts on socioeconomic resources/receptors. The evaluation criteria used to determine impact magnitude and sensitivity for specific socioeconomic resources/receptors are summarized in Chapter 4.

Stakeholder engagement is critical to a robust impact assessment process. A range of stakeholders were interviewed to deepen understanding of the existing socioeconomic conditions, potential impacts of the Project, and receptors’ sensitivity or vulnerability to change. This includes engagement conducted through scoping and development of the EIA for the Yellowtail Project in 2021 and engagement conducted for past offshore development projects.

The assessment presented in this chapter addresses potential impacts of the Project on the following socioeconomic resources/receptors within the Project AOI:

- Socioeconomic conditions
- Employment and livelihoods
- Community health and wellbeing
- Marine use and transportation
- Social infrastructure and services
- Waste management infrastructure and capacity
- Cultural heritage
- Land use
- Ecosystem services
- Indigenous Peoples

Because the Project’s primary planned activities are located approximately 203 kilometers (approximately 126 miles) northeast of the coastline of Georgetown, potential impacts on

socioeconomic resources/receptors as a result of planned Project activities are expected to be limited. The following are the main planned Project activities with the potential to result in socioeconomic impacts within Guyana:

- Installation, commissioning, start-up, and operation of the Floating Production, Storage, and Offloading (FPSO) vessel and Subsea, Umbilicals, Risers, and Flowlines (SURF);
- Drilling of development wells;
- Government revenue generated by the Project;
- Project-related employment and procurement;
- Presence of foreign Project workers in the Georgetown area;
- Project use of emergency and health services in the Georgetown area;
- Project-related road and air transportation activity in the Georgetown area;
- Project use of utilities and accommodations in the Georgetown area;
- Project use of waste management infrastructure in the Georgetown area; and
- Marine vessel transits between the Project Development Area (PDA) and shorebase facilities in Guyana and between the PDA and shorebase facilities in Trinidad (in Guyanese territorial waters).

The categories of receptors considered in the assessment of potential socioeconomic impacts from planned Project activities are outlined in Table 8-1, along with the rationale for their inclusion and the potential impacts that could affect them. Potential impacts related to unplanned events (e.g., oil spill scenarios) are addressed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

Table 8-1: Socioeconomic Receptors and Associated Potential Impacts from Planned Project Activities

Receptor	Rationale for Inclusion	Potential Impacts
General Guyanese population	The Project could have far-reaching economic impacts throughout the country, which could potentially affect all segments of the population, including in the hinterlands.	• Increased government revenues, potentially leading to increased social spending and investment throughout the country • Increased business activity and related employment
General population of Georgetown	The limited amount of time offshore-based foreign Project workers will be on shore will likely be spent in transit (e.g., to/from airports or hotels). Onshore-based foreign Project workers will principally reside in Georgetown, where they will interact with the local population and make use of the same resources and infrastructure as the local population.	• Changes to community dynamics, identity, and sense of safety/security • Increased risk of communicable disease transmission (see Section 8.3, Community Health and Wellbeing)

Receptor	Rationale for Inclusion	Potential Impacts
	Project procurement and Project worker spending level may result in higher demand for goods and services.	• Increased cost of living
	The Project may result in induced influx of job seekers from other areas of Guyana to the Georgetown area.	• Increased risk of communicable disease transmission • Increased competition for employment
	The Project may rely, in a very limited manner, on some medical and health facilities in the Georgetown area to address worker illness and injury.	• Decreased accessibility of medical and health services
Road users in Georgetown (both motorized and non-motorized [e.g., cyclists, pedestrians])	The Project will use existing roads for transporting workers, materials, equipment, and wastes to/from the shorebases and offices/residences.	• Increased traffic congestion • Increased risk of property damage and injury from vehicle accidents
Marine vessel operators (including but not limited to fisherfolk and speedboat operators) in Georgetown Harbour and along the coast	The Project will involve transit of various marine vessels, such as support vessels and tugs, between the Georgetown-area shorebase facilities and the PDA.	• Increased marine traffic congestion (on the order of 1–3%) in Georgetown Harbour and coastal waters between Georgetown-area shorebase facilities and the PDA • Increased risk of marine accidents
Marine vessel operators in the vicinity of the PDA	The Project will establish marine safety exclusion zones around the FPSO, drill ships, and major installation vessels, precluding use of these areas for other activities such as deep-sea fishing.	• (Very limited) reduced availability of ocean areas for non-Project livelihood activities such as deep-sea fishing
Archaeology and heritage resources	The Project will disturb the seafloor in the process of drilling development wells, installing FPSO mooring components, and installing SURF components.	• Damage to underwater archaeological or heritage sites, if present

8.1. SOCIOECONOMIC CONDITIONS

This section describes the existing socioeconomic characteristics of the Project AOI, with a focus on the shore zone, or coastal areas. It was developed based on secondary information contained in Project-related materials, socioeconomic reports and data obtained through government entities and other stakeholders, and other relevant data received from public sources. At the time of writing, the most recent national census was conducted in 2012 (BSG 2012); the next census is planned for 2022.

This section also incorporates information obtained directly from key informant interviews conducted from 2018 through 2021 with members of national, regional, and local governments; civil societies and NGOs; local community members (including fisherfolk); and other Project stakeholders. Specific stakeholder engagement information can be found in Section 4.7, Stakeholder Engagement.

8.1.1. Administrative Framework—Socioeconomic Conditions

Table 8.1-1 summarizes the legislation, policies, or treaty commitments that are specifically relevant to the assessment of potential impacts on economic conditions.

Table 8.1-1: Legislation, Policies, or Treaty Commitments—Socioeconomic Conditions

Title	Objective	Relevance to the Project
Legislation		
Natural Resource Fund Act (2019)	Establishes the National Resource Fund to manage the natural resource wealth of Guyana for the present and future benefit of the people and for the sustainable development of the country. The act also outlines governance and oversight mechanisms of the fund.	Provides for revenues from the Project to be deposited into the fund and used to finance national development, including initiatives aimed at achieving the government's vision of an inclusive green economy.
Local Content Act (2021)	Provides for the implementation of local content obligations for petroleum operations or related activities in the petroleum sector.	Directly influences Guyanese service provision and employment in the petroleum sector. Includes requirements to develop and submit local content plans, as well as auditing and reporting. Also establishes an official register of Guyanese nationals and Guyanese companies for employment and procurement, and provides detailed annual local content targets for certain sectors and sub-sectors. Establishes a Local Content Advisory Committee to provide recommendations and collaborate on strategic initiatives related to local content.

8.1.2. Existing Conditions—Socioeconomic Conditions

8.1.2.1. Administrative Divisions in Guyana

Guyana is divided into 10 administrative regions, pictured on Figure 8.1-1, which are overseen by Regional Democratic Councils (RDCs). These regions are further subdivided into 70 Neighbourhood Democratic Councils (NDCs) and 9 Town Councils (TCs) that are comprised of villages. Within the regions, there is a mixture of Community Development Councils (CDCs) for some villages and Village Councils (VCs) in titled Amerindian villages. In titled Amerindian villages, the VCs are empowered by the Amerindian Act (2006) to act as village administrators and are comprised of the village leader (known as Toshao) and elected councilors. Elections are held in villages every 3 years to establish the VCs.

Figure 8.1-1: Guyana's Administrative Regions and Townships

In Guyana there is one city that serves as the capital (Georgetown) and nine other townships. In 2015, three of these townships were gazetted as new townships by the Ministry of Communities[1] as part of an administrative decentralization effort. Decentralization continued in 2018 when Mahdia (in Region 8) was gazetted as a township. Georgetown is administered by a mayor and City Council. The townships have mayors and councils. Georgetown and the nine townships serve as an administrative hub for government services, such as passports and driver's licenses. They also provide utilities and public services, such as water and sanitation and banking. Of the 10 administrative regions, this EIA is focused on the shore zones or coastal areas in Regions 1, 2, 3, 4, 5, and 6. Together, Regions 2 through 6 account for 49 NDCs, 4 TCs, and 1 City Council in Georgetown. Within Region 1, the near-coastal area is comprised of 13 VCs/CDCs and 1 TC.

Region 1

- Father's Beach Community
- Manawarin Community
- Haimokabra[2] Community
- Waramuri Community
- Santa Rosa Community
- Assakata Community
- Warapoka Community
- Three Brothers Community
- Mabaruma Town Council
- Aruka Mouth Community
- Morawhanna Community
- Smith's Creek Community
- Imbotero Community
- Almond Beach Community

Region 2

- Charity/Urasara
- Evergreen/Paradise
- Aberdeen/Zorg-en-Vlygt
- Anna Regina Town Council
- Annandale/Riverstown
- Good Hope/Pomona

Region 3

- Wakenaam (island)
- Leguan
- Mora/Parika
- Hydronie/Good Hope
- Greenwich Park/Vergenoegen
- Tuschen/Uitvlugt
- Stewartville/Cornelia Ida
- Hague/Blankenburg
- La Jalousie/Nouvelle Flanders
- Best/Klien/Pouderoyen
- Moruka/Phoenix Park
- Nile/Cozier

Region 4[3]

- Georgetown
- Industry/Plaisance
- Better Hope/La Bonne Intention
- Beterverwagting/Triumph
- Mon Repos/La Reconnaissance
- Buxton/Foulis
- Unity/Vereeniging
- Haslington/Grove
- Enmore/Hope
- Haslington/Golden Grove
- Cane Grove

Region 5

- Woodlands/Farm
- Hamlet/Chance
- Profit/Rising Sun
- Mahaicony/Abary
- Union/Naarstigheid

[1] Now the Ministry of Local Government and Regional Development
[2] Haimokabra is considered a satellite village of and shares leadership with Waramuri.
[3] Region 4 list is limited to coastal communities, and does not include inland or riverside communities.

- Seafield/Tempie
- Bath/Woodley Park
- Woodlands/Bel Air
- Zeelust/Rosignol

Region 6

- Ordinance/Fort Lands No. 38
- Kintyre/No. 37
- Gibraltar/Fyrish
- Kilcoy/Hampshire
- Rose Hall Town Council
- Port Mourant/John
- Bloomfield/Whim
- Lancaster/Hogstye
- Black Bush Polder
- Good Hope/No. 51
- Macedonia/Joppa
- Bushlot/Adventure
- Maida/Tarlogie
- No. 52/No. 74
- Corriverton Town Council
- Plegt Anker/Kortberaadt
- Wyburg/Caracas

8.1.2.2. Population Distribution

Most of Guyana's population is located in the six coastal regions; according to the 2012 national census (BSG 2002; BSG 2012), nearly half of the country's population lives in Region 4 (Demerara-Mahaica), which includes the capital city of Georgetown. Table 8.1-2 summarizes the distribution of population within the 10 regions in 2012, the last year for which complete national census data are available. According to the Bureau of Statistics, Guyana's next national census will commence in 2022 to avoid conflicting with Guyana's General and Regional Elections. On an annual basis, the Bureau updates population projections using records of births, deaths, and migration, but these projections are not publicly released (ERM/EMC Personal Communication 9).

Table 8.1-2: Regional Population Distribution in Guyana

Region		Population 2002	Population 2012	Percentage Population Change (2002–2012)	Percent of Guyana's Total Population
1	Barima-Waini	24,275	27,643	+13.9%	3.7%
2	Pomeroon–Supenaam	49,253	46,810	-5.0%	6.3%
3	Essequibo Islands—West Demerara	103,061	107,785	+4.6%	14.4%
4	Demerara-Mahaica	310,320	311,563	+0.4%	41.7%
5	Mahaica—Berbice	52,428	49,820	-5.0%	6.7%
6	East Berbice—Corentyne	123,695	109,652	-11.4%	14.7%
7	Cuyuni-Mazaruni	17,597	18,375	+4.4%	2.5%
8	Potaro—Siparuni	10,095	11,077	+9.7%	1.5%
9	Upper Takutu—Upper Essequibo	19,387	24,238	+25.0%	3.2%
10	Upper Demerara—Berbice	41,112	39,992	-2.7%	5.3%
	Guyana	748,084	746,955	-0.6%	100.0%

Sources: BSG 2002, 2012

Note: Each region's change in population should be weighted based on that region's percent of the total population; therefore, the sum of percentage population changes in each region do not add up to the total national percentage population change.

Population and other demographic information have not been historically collected or available at the NDC/CDC/VC/TC level; however, informal data collected from engagement with NDCs and CDCs/TCs by the Consultants in late 2017 and early 2018 (ERM/EMC 2018) and 2019 (Appendix S, Enhanced Coastal Sensitivity Mapping—Ecosystem Services Final Report) provide some estimates of the population ranges for coastal communities, as described below:

- Region 1: As of mid-2019, each CDC/VC/TC population ranged from approximately 100 to 500 people, with the exception of Father's Beach (23 people), Waramuri and Manawarin (approximately 2,000 and 2,500, respectively) and Mabaruma Town Council and Santa Rosa (approximately 8,000 and 10,500, respectively).
- Region 2: As of mid-2019, each NDC population ranged from approximately 6,000 to 10,900, with the exception of Anna Regina Town Council (approximately 22,000).
- Region 3: As of early-2018, NDCs had several thousand people each. The larger coastal NDCs ranged in population from Mora/Parika at approximately 10,000, to Best/Klien/Pouderoyen at approximately 20,000, and Tuschen/Uitvlugt and Stewartville/Cornelia Ida at approximately 30,000 each.
- Region 4: As of mid-2019, Georgetown's population was estimated at 132,000. The populations of Industry/Plaisance, Haslington–Golden Grove, Better Hope/La Bonne Intention, and Mon Repos/La Reconnaissance were estimated at 25,000, 27,000, 30,000, and 40,000, respectively. The other NDC populations ranged from 7,000 to 13,000.
- Region 5: As of mid-2019, Woodlands/Bel Air, Bath/Woodley Park, and Woodlands/Farm were estimated at approximately 15,000, 18,000, and 20,000, respectively. The other NDC populations averaged a few thousand each, up to an estimated 8,000.
- Region 6: As of early-2018, the Kilcoy/Hampshire NDC population was estimated at 30,000. Several other NDCs average in population between 10,000 and 15,000; most of the smaller NDCs had an average population of a few thousand each.

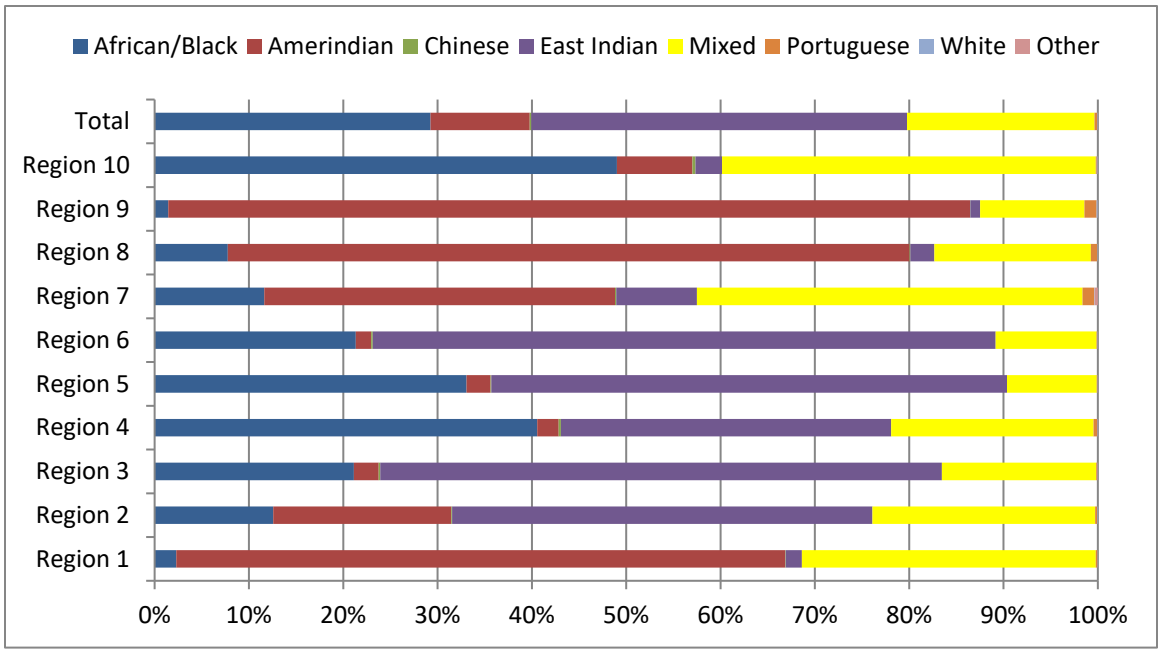
According to the data collected in 2021 and reports in the local media, many of the VC and CDCs in Regions 1 and some NDCs and TCs in Region 2 reported an increase in population over the last two decades, mainly a result of an influx of returning Guyanese and native Venezuelans with Amerindian ties.

Ethnic Composition

Data from the 2012 national census (BSG 2012) indicate that the majority of the population is from two ethnic groups: East Indian descent (39.8 percent) and African descent (29.3 percent). These are followed by populations of mixed ethnicity (19.9 percent) and Indigenous Peoples who are referred to as Amerindians (10.5 percent). Other ethnicities, including Chinese, white, and Portuguese, collectively make up less than one percent of the population.

Figure 8.1-2 shows the ethnic composition of each region and indicates notable differences between interior and coastal regions and between regions that are highly rural versus more urban. The more populated and urban Regions 3, 4, 5, and 6 are dominated by populations of

East Indian and African descent, followed by populations of mixed ethnicity. Amerindian population numbers in these regions are low. The majority residing in the more remote and rural regions (Regions 1, 8, and 9) are of Amerindian ethnicity.



Source: BSG 2012

Figure 8.1-2: Regional Distribution of Ethnicity, 2012

Indigenous Peoples

See Section 8.10.2, Existing Conditions—Indigenous Peoples, for information on existing conditions for Indigenous Peoples.

8.1.2.3. Education

Guyana's Constitution states that school attendance is compulsory up to the age of 15. Primary and secondary education is free. The Ministry of Education controls education budgets, policies, and standards, and administers these by districts. The country is divided into 11 education districts, 10 of which correspond with the administrative regions; Georgetown makes up the eleventh district.

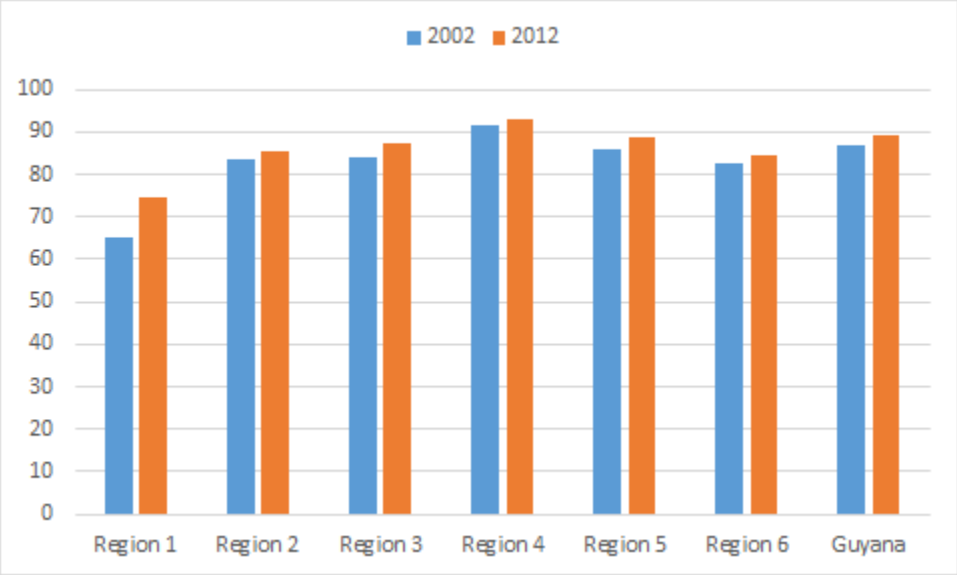
In 2021, $60.7 billion Guyanese dollars (GYD) (approximately $304 million U.S. dollars [USD]), or 15.8 percent of the national budget, was allocated to the education sector (Khan 2021). This is consistent with prior years, as an average of 15 percent of the national budget has been allocated to education since 2009 (Ministry of Education 2014).

Literacy

The adult literacy rate (defined as the percent of population age 15 and above that can read and write) increased by 2.5 percent between the 2002 and 2012 censuses. The lowest level of

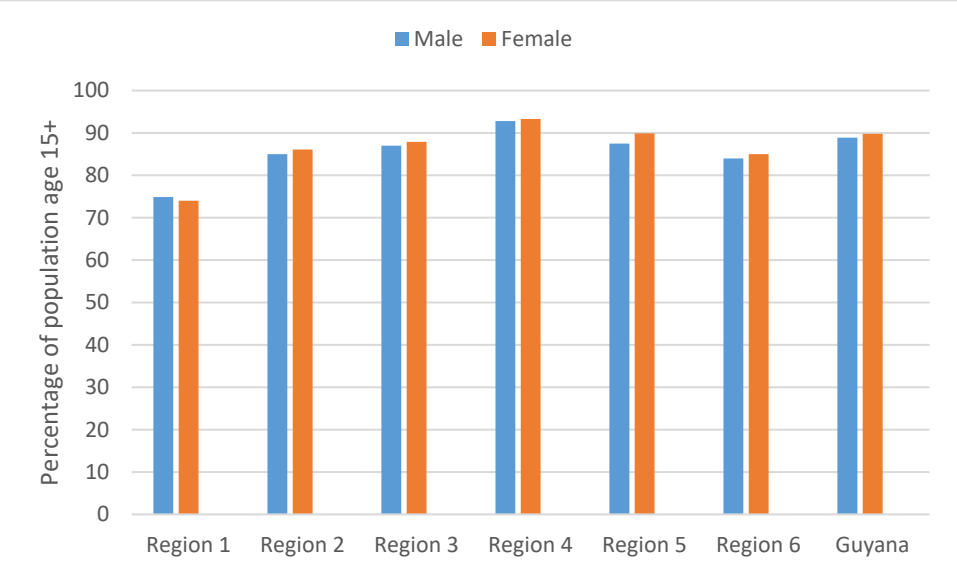
literacy exists in Region 1, but the 2012 census showed considerable improvement (a 9.4 percent increase) over the rate measured in the 2002 census (BSG 2002; BSG 2012; see Figure 8.1-3).

Gender differences in literacy are minimal among the regions, with the female population showing a slightly higher rate of literacy than males across most of the coastal regions and the country as a whole (Figure 8.1-4).



Source: BSG 2012

Figure 8.1-3: Adult Literacy Rate, 2002 and 2012

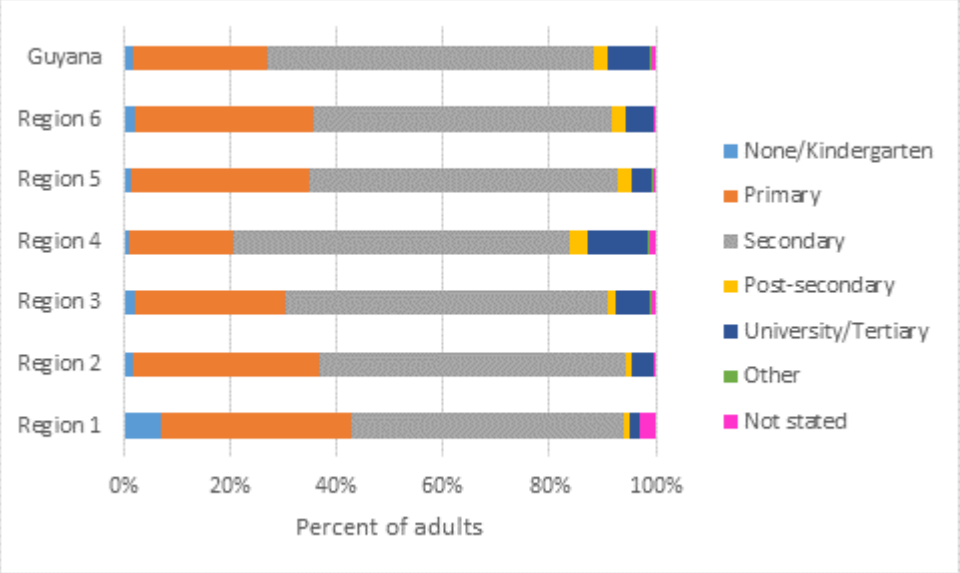


Source: BSG 2012

Figure 8.1-4: Adult Literacy Rate by Gender, 2012

Educational Attainment

Guyana has made progress in achieving universal primary education, but the education system still faces issues regarding access to education at the secondary level and quality issues across all levels of schooling. The percentage of children in Guyana attending secondary school was estimated at 84.5 percent in 2014 (World Bank 2016). Data from the 2012 census indicate that the majority of adults in Guyana at the time had attained the secondary level as their highest level (Figure 8.1-5). Of the coastal regions, educational attainment was lowest in Region 1.



Source: BSG 2012

Figure 8.1-5: Highest Educational Attainment Level, 2012

The levels of primary education for the indigenous population are typically lower than for non-indigenous groups of the population. In Amerindian communities, the attendance rate at primary schools has been reported to be 50 percent lower than the average for Guyana (Minority Rights Group International 2008). Further, only 53 of every 100 students in indigenous communities complete secondary school (UNICEF 2017). This is partly attributable to a shortage of infrastructure, utilities, qualified teachers (Ministry of Education 2014), and financial constraints of families (UNICEF 2017). Standardized teaching methods and curricula are not aligned to indigenous culture and values, and this contributes to lower-than-average attendance rates. While access to education in Amerindian communities continues to be limited, the stated government policy is to provide indigenous children with the same educational opportunities available to the rest of the population (Minority Rights Group International 2008). The Government of Guyana has made several interventions to bridge the gap between hinterland and indigenous quality of education and those of the coastland. Among the interventions are the implementation of smart classrooms in indigenous schools, internet access for students and teachers, remote and distance training of teachers, and the piloting of teaching in indigenous languages (Government of Guyana 2021; News Room Guyana 2021).

8.1.2.4. Economic Conditions

Economic Overview

Guyana was reclassified by the World Bank from a lower middle-income country to an upper middle-income country in 2016 (World Bank 2016), and continues to hold this status (World Bank 2021). Guyana's economy grew by 43.5 percent in 2020, up from 5.4 percent growth in 2019. This increase was due mainly to the country's first year as an oil-producing nation. However, not all sectors of the economy grew in 2020, as outputs of sugar, rice, gold, and fishing declined (Bank of Guyana 2021), and economic activity across the country was negatively impacted by the coronavirus disease 2019 (COVID-19) pandemic. Although gross domestic product (GDP) grew by 43.5 percent overall, non-oil GDP actually contracted by 7.3 percent by the end of 2020, compared to a 4.3 increase in the same period in 2019.

Guyana's main sectors by contribution to GDP in 2020 are summarized in Table 8.1-3.

Table 8.1-3: Economic Sectors and Contribution to GDP at Current Basic Prices in 2020

Sector	Percent of GDP
Agriculture, Fishing, and Forestry	18.13%
Mining and Quarrying (including petroleum and gas)	29.17%
Wholesale and Retail Trade	5.2%
Transportation and Storage	2.97%
Construction	7.15%
Manufacturing	4.56%
Public Administration	6.55%
Information and Communication	2.29%
Financial and Insurance Activities	4.04%
Education	3.06%
Other Services	0.23%
Health and Social Services	1.74%
Electricity and Water	0.86%
Real Estate	8.31%

Source: Bank of Guyana 2021

Note: Percentages do not add to 100 percent (likely in part due to rounding) but have been verified by the Consultants to be as-reported in the referenced source.

Guyana relies heavily on trade, with exports totaling $558.79 billion GYD ($2.794 billion USD) in 2020, up from $338.47 billion GYD ($1.692 billion USD) in 2019 (Bank of Guyana 2021). The main export products for the country are sugar, rice, bauxite, gold, forest products, and—as of 2020—crude oil (FAO 2015; Bank of Guyana 2021). In 2020, exports of sugar, timber, and other exports declined 13.4 percent, 17.9 percent, and 37 percent, respectively. Oil exports began in 2020, amounting to 26.6 million barrels (4.3 million cubic meters [m^3]) over the year valued at approximately $222.376 billion GYD ($1.112 billion USD).

The investment climate and financial infrastructure in Guyana is still maturing, and the country has faced challenges in attracting investments and diversifying the economy. According to the

World Bank, the overall business regulatory framework remains complex and cumbersome. A challenging regulatory environment for businesses particularly affects micro-, small-, and medium-sized enterprises, which account for most businesses in Guyana (World Bank 2016). In 2020, as in prior years, Guyana ranked 134 out of 190 world economies for ease of doing business (World Bank 2020).

The economic importance of the oil and gas sector, sectors that are particularly important for the coastal areas (i.e., where the potential for socioeconomic effects from the Project is higher, as compared to the rest of the country), as well as the mining and wholesale/retail trade sectors (which are important sectors for the country as a whole), are described in further detail below.

Petroleum, Gas and Support Services

Oil production in Guyana commenced in December 2019 and Guyana became an oil-exporting nation in 2020. The oil reserves of Guyana are estimated at 9 billion barrels (1.4 billion m^3) of oil equivalent resource with still unexplored and potentially undiscovered additional reserves; offshore exploration activities are ongoing.

Categorized as part of the Mining and Quarrying sector (described further below), the "Petroleum & Gas & Support Services" sector expanded substantially in 2020 (Bank of Guyana 2021). This was the first full year of crude oil production, amounting to over 27 million barrels (4.3 million m^3) in 2020, compared to just over 427,000 barrels (68,320 m^3) in 2019. Oil production averaged 74,300 barrels (11,888 m^3) per day over the year, peaking at 120,000 barrels (19,000 m^3) per day in December 2020. Overall, the sector contributed more than $180.39 billion GYD ($901.95 million USD) to the national GDP in 2020, representing 17 percent of total GDP at basic prices, compared to 1.9 percent in 2019.

In 2019, the Bureau of Statistics anticipated that as a result of the oil and gas sector, GDP may increase up to 13 times and the Guyanese dollar will appreciate in value against the USD once daily production reaches 1 million barrels per day (160,000 m^3 per day); ERM/EMC Personal Communication 9). In addition to impacts on GDP through fiscal revenue, there will also be opportunities to boost economic growth through increased foreign direct investment in supporting goods and services in the time leading up to oil production, which will present the country with opportunities to diversify production and trade. Nonetheless, the economy's increased dependence on natural resources will also increase its vulnerability to commodity price fluctuations and could reduce the competitiveness of other sectors (IDB 2017).

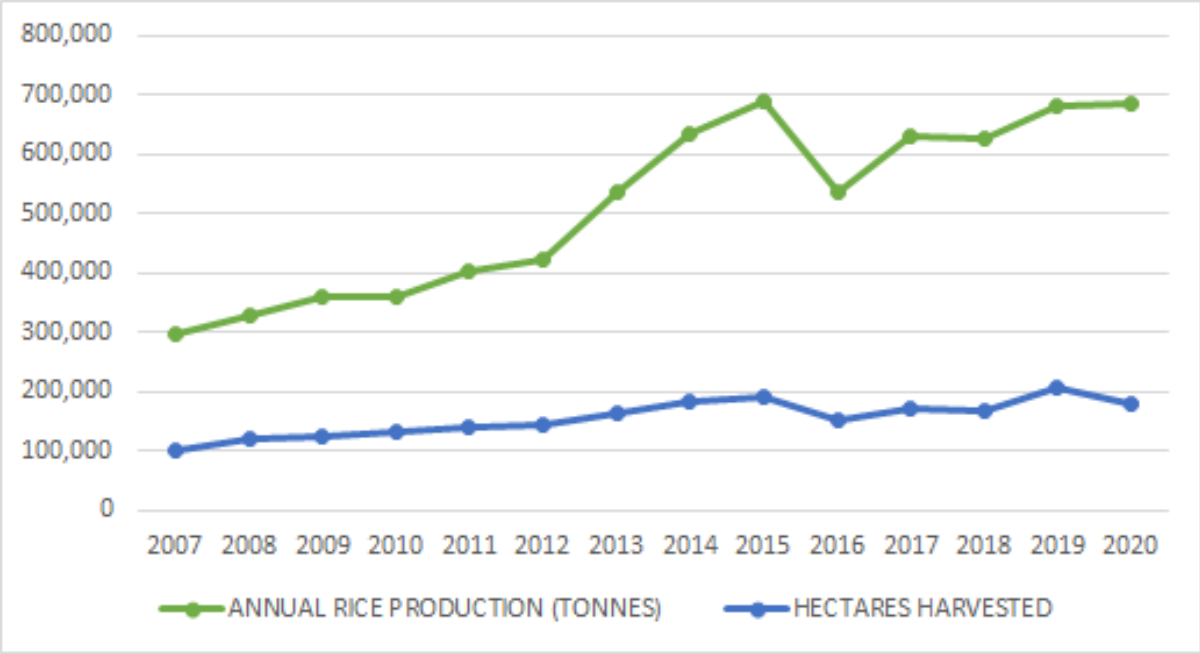
Agriculture

According to the Private Sector Commission (PSC), Guyana has a relatively strong agricultural sector and is the only net exporter of food in the Caribbean. In 2020, the agriculture sector (including sugarcane, rice, other crops, and livestock) grew by 4.5 percent over the prior year, compared to a 0.3 percent increase between 2018 and 2019, and a 14.7 percent decline between 2017 and 2018. The increase in 2020 was attributed to higher outputs of sugarcane, rice, and other crops (Bank of Guyana 2021). The agriculture sector represented 16.2 percent of Guyana's GDP at basic prices in 2020, down from 17.0 percent in 2019, 18.3 percent in 2018,

and 21.4 percent in 2017. This follows a general downward trend of the contribution of the agriculture sector to national GDP over the past decade (Bank of Guyana 2021). The Ministry of Agriculture is currently drafting a revised National Agriculture Strategy for 2020 to 2025 that will take into consideration the burgeoning oil and gas sector and its interaction with agriculture (ERM/EMC Personal Communication 7).

Rice

In 2020, rice production increased by 0.7 percent to 687,427 tonnes, up from 682,081 tonnes in 2019 (see Figure 8.1-6). This increase is linked to a 4.4 percent increase in the hectares of rice production, although there was also a 3.5 percent decrease in yield per hectare due to various diseases that affected the second crop in 2020 (Bank of Guyana 2021). In 2018, rice production was notably lower at 626,684 tonnes; this low production was attributed to poor weather conditions, paddy bug infestation, fewer hectares harvested, and lower investments in the sector (Bank of Guyana 2018). The main export markets for Guyana's rice are the European Union, Caribbean Community (CARICOM), Mexico, West African countries, and Latin America (Bank of Guyana 2019).



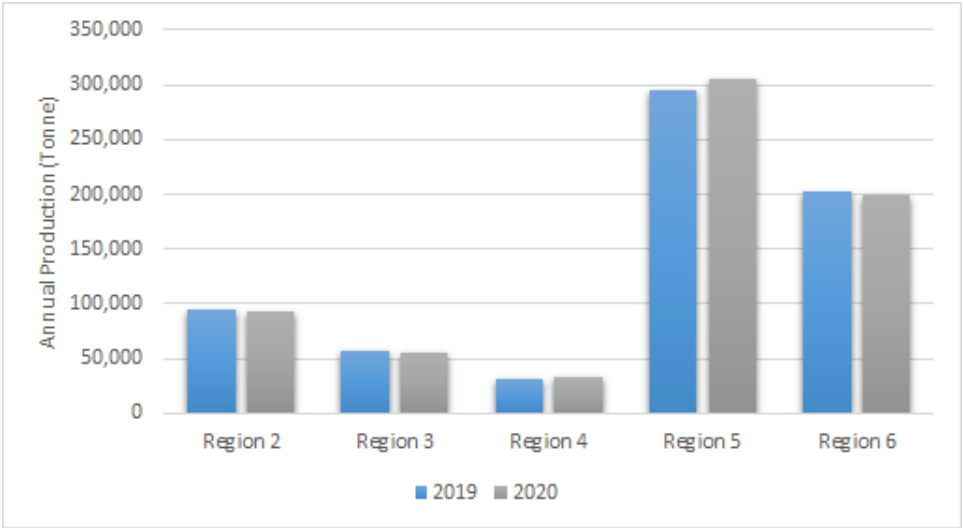
Sources: Ministry of Agriculture 2018; Bank of Guyana 2019; Guyana Rice Development Board 2021

Figure 8.1-6: Annual Rice Production and Hectares Harvested, 2007–2020

Rice is especially important in several coastal NDCs, where it is cultivated for both commercial and subsistence use (ERM/EMC 2018), and rice fields dominate the landscape in many coastal areas in these regions (Figure 8.1-7). Many communities have reported that the heavy flooding across Guyana in 2021 had a significant negative effect on local rice farming.

Figure 8.1-7: Rice Field in Region 2 Pomeroon-Supenaam

Rice farming is the predominant agricultural activity in the coastal areas of Regions 2, 3, 5, and 6. In 2016, rice production accounted for an estimated 85 percent of the overall economy in Region 2, and 55 to 60 percent in Region 3 (ERM Personal Communication 1). Region 5 had the largest rice industry, with more than 80,000 hectares harvested in 2018 compared with approximately 28,800, 15,400, 7,000, and 40,000 hectares (71,166.1, 38,054.1, 17,297.3, and 98,841.8 acres) harvested in Regions 2, 3, 4 and 6, respectively. Consequently, annual rice production is highest in Region 5. Between 2019 and 2020, rice production was relatively stable across all of these regions, with a slight increase in production in Region 5 (Figure 8.1-8).



Source: Guyana Rice Development Board 2021

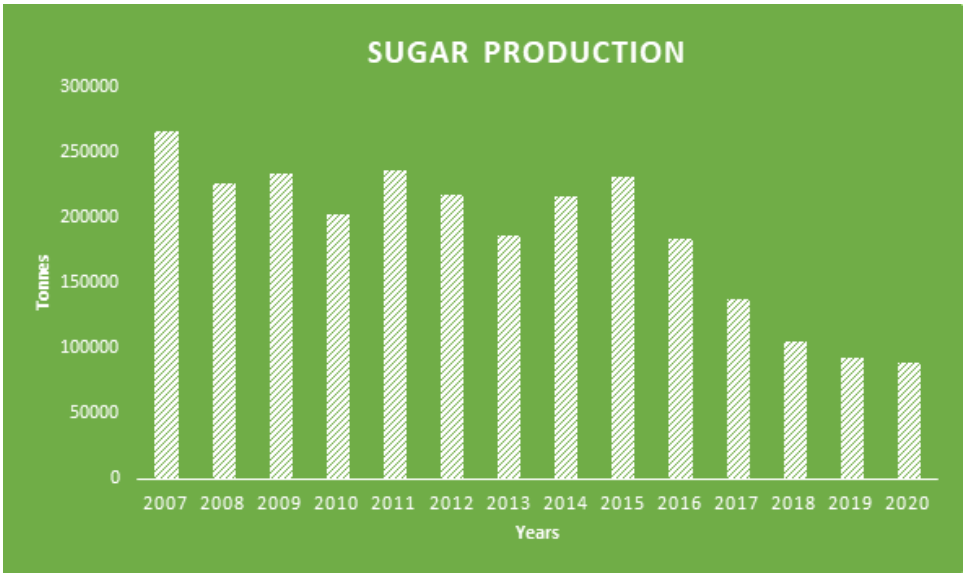
Figure 8.1-8: Annual Rice Production in Regions 2 to 6

According to the president of the Guyana Rice Producers' Association, industrial rice production requires the ability to precisely control water levels in the rice fields. The rice growers in coastal Guyana achieve this by operating two separate systems of canals, one dedicated to irrigation and another dedicated to drainage. The irrigation canals convey fresh water from water conservancies or rivers via gravity to the rice fields. The rice fields are contained within a dike system that has separate gates for irrigation and drainage systems. The fields drain to a separate network of canals constructed to provide general drainage to the surrounding coastal landscape (ERM Personal Communication 1). These canals drain to the Atlantic Ocean via manually operated mechanical sluice gates (locally called *kokers*; see Figure 8.1-9) or by pump stations installed along the coastline. The drainage canals are generally constructed at or very near sea level to achieve the gradient necessary for drainage of the surrounding landscape. Therefore, the drainage canals are tidally influenced and the kokers control inflow from the sea. This system ensures that the rice fields remain upgradient of tidally influenced water in the drainage canals and prevents salt water from intruding into the fields (ERM Personal Communication 1; ERM/EMC 2018).

Figure 8.1-9: Sluice Gate (Koker) in Charity (Region 2) at High Tide

Sugar

In 2020, sugar production declined to 88,890 tonnes, down from 92,232 tonnes in 2019, 183,491 tonnes in 2016, and 231,076 tonnes in 2015 (Figure 8.1-10). Sugar production in 2020 represented the lowest quantity of sugar produced over the last decade. This outcome in 2020 compounded declines in prior years, and can be attributed to mechanical failures in two factories, unfavorable weather conditions, and the effects of the pandemic which affected worker turnout (Bank of Guyana 2021).



Sources: Ministry of Agriculture 2018; Bank of Guyana 2021

Figure 8.1-10: Annual Sugar Production, 2007–2020

As production levels were reduced, the value of sugar, as indicated by its average export price, increased by 4.5 percent in 2020. This increased value somewhat offset the 17.1 percent decline in export volumes, although export earnings still declined from $5,810.2 million GYD ($29.1 million USD) in 2019 to $5,036.9 million GYD ($25.2 million USD) in 2020. Overall, the average export price for sugar was $77,685 GYD ($388.3 USD) per metric tonne in 2020, compared to $74,362.2 GYD ($371.8 USD) per tonne in 2019, $72,899.2 GYD ($364.5 USD) per tonne in 2018, and $92,566.1 GYD ($462.8 USD) per tonne in 2017 (Ministry of Agriculture 2018; Bank of Guyana 2021). Guyana's Demerara sugar is exported to markets in the European Union, United States, and CARICOM countries. Commercial farms growing sugarcane are found primarily along the coastal areas in Regions 4 and 6 (see Figure 8.1-11; ERM/EMC 2018).

Figure 8.1-11: Aerial View of Sugar Plantations

Coconut

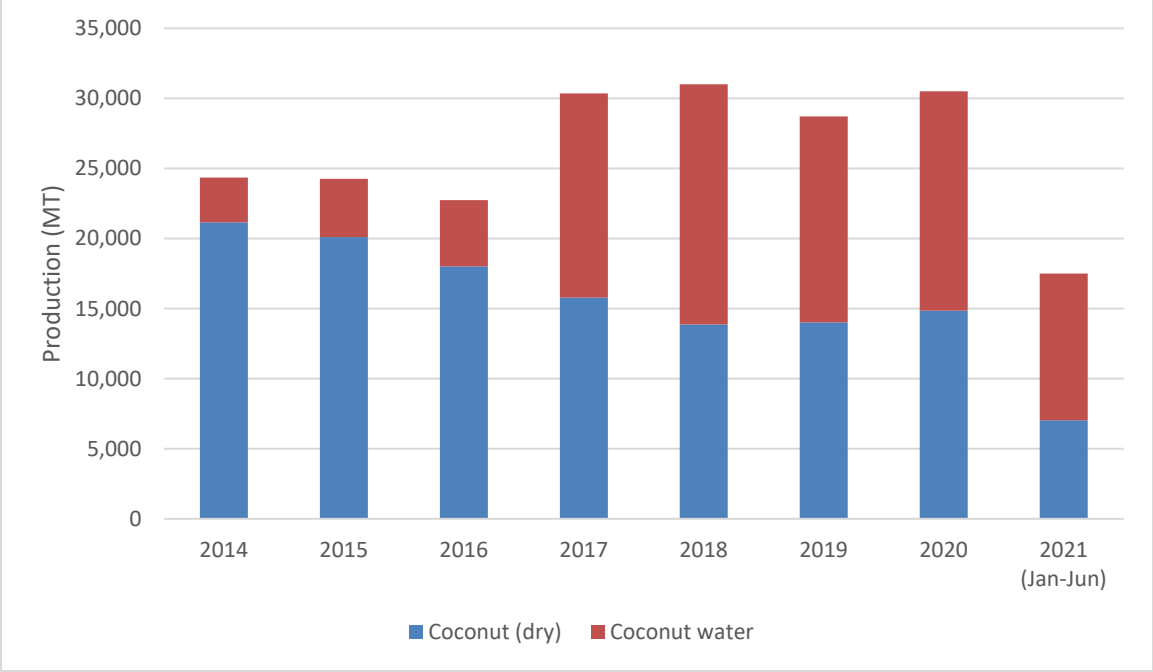
The coconut industry in Guyana has grown in recent years (Figure 8.1-12) and shows potential for continued growth due to high international demand for products such as coconut oil and coconut water. As of 2020, approximately 24,000 hectares (59,305 acres) of coconuts were being cultivated (up from 10,000 hectares [2,471 acres] in 2015), and the National Agricultural Research and Extension Institute estimates that acreage dedicated to coconut cultivation could quadruple from the 2015 baseline by 2025 (Stabroek News 2018).

In 2016, a Coconut Festival was held in Guyana through a collaborative effort of the Ministry of Business,[4] the Ministry of Agriculture, the International Trade Centre and the Caribbean Research and Development Institute to build awareness of the coconut industry and to promote

[4] Now the Ministry of Tourism, Industry and Commerce

investments (NAREI 2017). Following this, a Coconut Board was convened by the International Trade Centre to focus on the development of Guyana's coconut industry and promote collaboration with the government and private sector operators (ERM/EMC Personal Communication 5).

Within the agricultural sector, the coconut industry ranks third after rice and sugar in terms of acreage; coconut is grown primarily in the coastal regions, including along the Pomeroon River and the Essequibo Coast in Region 2. According to news media articles, the amount of land in the Pomeroon area being converted to coconut cultivation is increasing (Guyana Chronicle 2016; Stabroek News 2016). In 2017, coconut production was 136,603 tonnes, of which 9,068 tonnes were exported. Value-added coconut products exported in 2017 included coconut choka, grated coconut, coconut water, and crude coconut oil (Ministry of Agriculture 2018). In 2021, coconut cultivation in Region 2 was affected by massive flooding across the region.



Source: Ministry of Agriculture 2021d

Figure 8.1-12: Annual Production of Coconuts and Coconut Water, 2014–2021

The coconut industry is active in all six of the coastal regions (ERM/EMC 2018), including the coastal NDCs/CDCs listed in Table 8.1-4. However, recent events have affected local coconut farmers in some Region 1 communities, including flooding and severe tides eroding coconut farmland, and the loss of export markets (e.g., Trinidad and Tobago) during the COVID-19 pandemic (ERM Personal Communication 32).

Figure 8.1-13: Coconut Plantation, Region 2

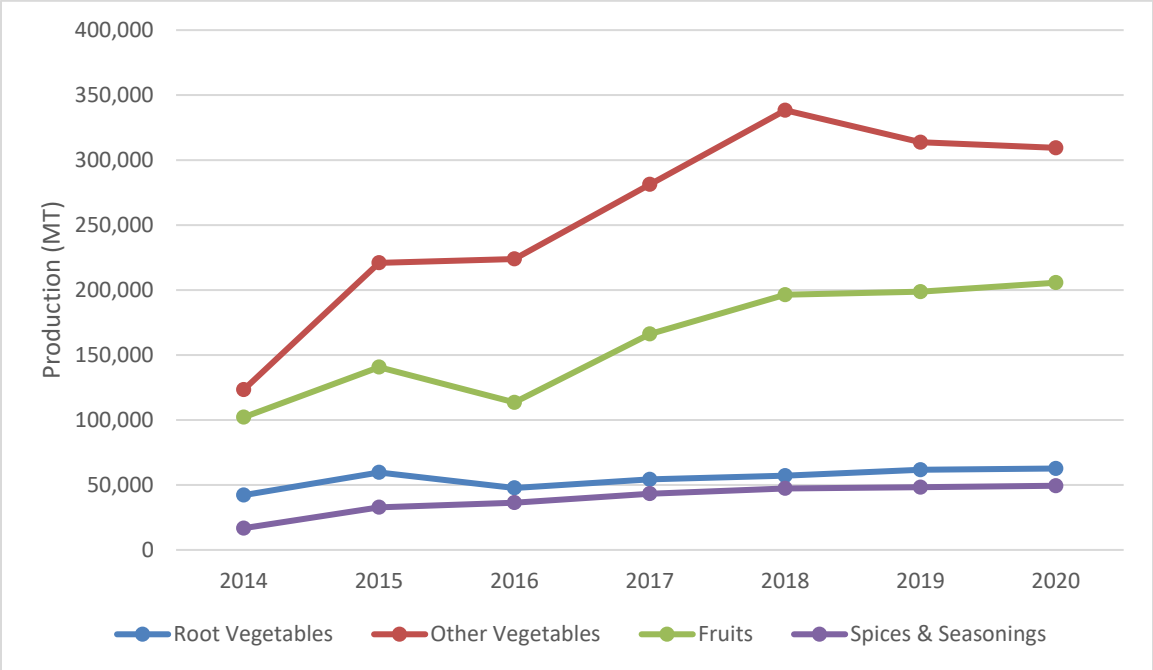
Table 8.1-4: Coastal NDCs/CDCs with Coconut Farming

Region	NDC/CDC Name
Region 1	Father's Beach
	Almond Beach
Region 2	Charity/Urasara
	Anna Regina Town Council
Region 3	Wakenaam (island)
	Leguan
	Mora/Parika
	Tuschen/Uitvlugt
	Stewartville/Cornelia Ida
Region 4	Industry/Plaisance
	Unity/Vereeniging
Region 5	Seafield/Tempie
	Union/Naarstigheid
	Bath/Woodley Park
	Woodlands/Bel Air
Region 6	No. 52/No. 74 Villages

In most cases, coconut farming is conducted for both subsistence and commercial reasons, and ranges in reported importance by stakeholders from low to essential (Appendix S, Enhanced Coastal Sensitivity Mapping—Ecosystem Services Final Report). There are instances where the expansion of coconut estates has resulted in the clearing of large swathes of mangrove forests, as is the case at the mouth of the Pomeroon River. However, coconut farming also supports Guyana's sea defense along sea dams through vegetative stabilization of the earthen coastal seawall.

Other Cash Crops

Non-traditional crops (i.e., crops other than sugar cane and rice) grown in Guyana include tubers such as cassava, sweet potato, and eddo; vegetables such as bora, eggplant, cabbage, cucumber, pumpkin, plantains, squash, tomatoes, and okra; spices such as hot peppers, eschallot, and ginger; and fruits such as avocado, banana, cherry, lime, orange, papaya, mango, passionfruit, watermelon, and pineapple. Data from the Ministry of Agriculture (2021a) show that production for all crop categories has generally increased over recent years. Growth in root vegetables and spices/seasonings has been more modest, whereas fruits and non-traditional crops have shown more substantial increases in production (Figure 8.1-14). Among fruits, papaya has shown the highest level of growth (1,104 percent) since 2014, along with orange (448 percent) and mango (217 percent). Increases in vegetables during this period include pumpkin (395 percent), eggplant (359 percent), and bora (208 percent), while sweet potatoes (323 percent) and ginger (475 percent) production also grew significantly.



Source: Ministry of Agriculture 2021a

Figure 8.1-14: Production of Other Cash Crops, 2014–2020

Similar to coconut farming, cash crops are grown in all six of the coastal regions (ERM/EMC 2018). In some cases, farmers, who are usually squatters, use the sea defense walls for agricultural purposes for subsistence and small-scale commercial sale. In Region 1, cassava is a primary staple in the diet, and villages that grow cash crops typically only sell them within their own villages (as transportation challenges restrict access to other markets). In many villages, cash crops are a primary source of both income and subsistence, supplementing fishing activities (ERM/EMC 2018).

In May to August 2021, Guyana experienced unprecedented flooding in all regions of the country. The floods severely impacted the cash crop growing areas of Regions 5 and 6. The floods destroyed crops and produce, and extensive and prolonged flooding in some areas will affect future production of cash crops (especially in areas already challenged by saline intrusion). In Region 1, livestock rearing has also been negatively impacted by flooding. NDCs in Region 5 reported a delay in the resumption of farming in some communities due to damaged farmland and lack of capital (ERM Personal Communication 33). The COVID-19 pandemic has also affected farmers due to reduced purchasing power, less spending in communities, and lower demand for produce from farmers.

Value-added Agricultural Products

According to various interviewed stakeholders, establishing manufacturing operations to develop value-added products such as pepper sauce, beverages, and canned fruit are priorities at both community and strategic policy levels (ERM Personal Communications 5, 10, 12, and 13; ERM/EMC Personal Communication 7). Several agricultural co-ops in Regions 2 and 3 have achieved varying levels of success in producing and marketing such products. National-level agencies such as the Ministry of Agriculture and the PSC emphasize the importance of developing markets for such products to provide better stability and security to farmers. However, there are a number of challenges associated with this, including high energy costs, difficulty locating or establishing markets for products, maintaining quality control and standards, packaging and labeling, and obtaining financing for start-up costs.

The private sector, through the Guyana Manufacturing and Services Association (GMSA), in partnership with the Ministry of Business[5], has been executing the *UncappeD* initiative, which has provided the opportunity for large and small agro-producers and processors from across the country to showcase their products at national-level expos and regional marketplace events. Several other related initiatives are also underway, including an Inter-American Development Bank (IDB)-supported project to improve the quality of national infrastructure, which would assist agro-processors. Many of these initiatives were reduced or suspended in 2020 in response to the COVID-19 global pandemic. However, the GMSA has established a web portal to facilitate information sharing and communication, connecting products and service providers with potential clients nationally, regionally, and internationally. Currently focused on the agro-processing sector, the GMSA plans to expand the portal to include the forestry and wood products and services sectors in subsequent phases.

According to the Ministry of Agriculture, value-added products are less volumetric and therefore easier to transport to markets. Consequently, promoting value-added production is an integral element of developing large-scale agriculture in hinterland areas. The Ministry of Agriculture, with support from the International Fund for Agricultural Development, is implementing a *Hinterland Environmentally Sustainable Agricultural Development Project* (2016 to 2023) in Mabaruma and Moruca (Region 1), which includes provision of support to local and regional councils to develop and implement investment plans through local value chains (ERM/EMC

[5] Now the Ministry of Tourism, Industry and Commerce

Personal Communication 7; IFAD Undated). The Ministry of Agriculture is also pursuing other initiatives including the creation of a research arm of the Guyana Rice Development Board to explore options for value-added rice products, encouraging blending of wheat flours with locally manufactured flours (cassava, sweet potatoes, rice), and establishment of a milk pasteurization plant in partnership with private operators (ERM/EMC Personal Communication 7).

In August 2021, the Ministry of Agriculture invested $26 million GYD ($130,000 USD) in the Guyana Marketing Corporation in the form of three all-terrain vehicles and two refrigerated trucks. The Guyana Marketing Corporation also launched its one-stop shop to better support farmers and marketers in marketing their produce (Parris 2021). Also in 2021, the United States Agency for International Development announced a partnership with local entity Guyana Economic Development Trust to launch an Economic Development Incubator and Accelerator (EDIA) for Guyanese agro-processors. The EDIA will address the technology base of agriculture processing in Guyana (Stabroek News 2021).

Fisheries and Aquaculture

Marine Fisheries

There are four main types of marine fisheries in Guyana (Ministry of Agriculture 2013), as differentiated by the species targeted, gear types used, and the depth of water where the fishery takes place. Table 8.1-5 summarizes the characteristics of these fisheries. Tuna, such as yellowfin tuna (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelamis*), have also been identified as a potential oceanic target species of commercial interest (Isaac and Ferrari 2017); however, the industrial tuna fishery in Guyana is small, as described in Section 8.2, Employment and Livelihoods.

Table 8.1-5: Primary Characteristics of Marine Fisheries in Guyana

Type of Fishery	Species	Gear	Depth
Industrial	Seabob, shrimps, and prawns	Trawls	Primarily from 13–16 meters (42.7–52.5 feet), but can occur from 0–75 meters (0–246.1 feet)
Semi-industrial	Red snapper and vermillion snapper	Fish traps and lines	Edge of continental shelf
Artisanal	Mixed fish and shrimp	Gillnets, drift seines, fyke nets/Chinese seines, and others (e.g., Cadell line)	0–28 meters (0–91.9 feet)
Shark	Various	Trawls, gillnets, and hook and line	Throughout the continental shelf waters

According to data from the PSC and the Ministry of Agriculture, fishery yields have generally declined since 2013 including the following annual trends:

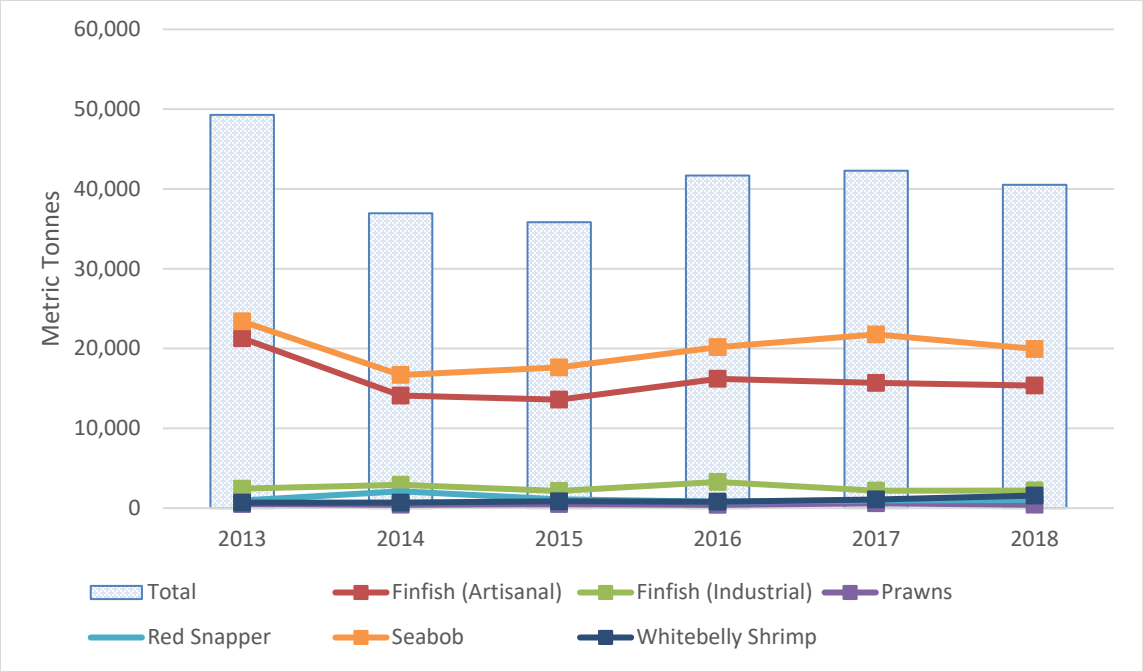
- Fishery yields declined between 2014 and 2015. The PSC attributes this to El Niño-related weather phenomena, while the Ministry of Finance characterizes this as part of a longer-

term decline caused by unsustainable overfishing, including illegal fishing by foreign vessels (Ministry of Finance 2015).

- The sector recovered in 2016 with growth in both fish and shrimp outputs. Fish output improved by 20.5 percent, and (total) shrimp output grew by 9 percent. However, prawn output fell by 17.8 percent (PSC 2017).
- In 2017, production continued with a very modest one percent overall increase. Shrimp and fish catch decreased by 6.2 percent and 1.2 percent, respectively, while prawn catch increased by approximately 4 percent between 2016 and 2017, and small shrimp catch grew by 8.9 percent (Bank of Guyana 2018).
- Fish catch continued to decline in 2018 with a 6.2 percent reduction compared with 2017 (Bank of Guyana 2019). These changes were attributed to market challenges arising from rigorous international certification requirements and an intrusion of sargassum seaweed (Bank of Guyana 2019).
- In 2019, fish catches increased by 21.4 percent, largely due to growth in local demand. However, shrimp catches were reduced by 25.1 percent, associated with the intrusion of sargassum seaweed (Bank of Guyana 2019).
- Fish catch in 2020 showed a marked reduction of 17.1 percent, compared to 2019, attributed to COVID-19 restrictions and related changes in demand for fishery products. Additionally, shrimp catch decreased by 14.3 percent due to weather conditions and an extended closed season for shrimp fishing (Bank of Guyana 2021).
- In general, during the COVID-19 pandemic, many companies working in the fishing industry have reduced the number of staff working on a given day. Fisheries plants were closed between April and August 2020, as a result of COVID-19 restrictions, and a reduced number of vessels went out to sea (resulting in lower fishing production) throughout the year (ERM Personal Communication 21).

According to the Fisheries Department, reasons for the decline in fish catch can generally be attributed to either the depletion or the migration of stock. The Fisheries Department has a program of reviewing stock assessments of seabobs and bycatch to further understand recent trends (ERM/EMC Personal Communication 4). Fishing interests and the Fisheries Department personnel also acknowledged the prevalence of illegal fishing by both foreign and domestic vessels, but did not specifically implicate illegal fishing in the decline of stock in recent years (ERM Personal Communications 2, 12, 13, and 14).

Fishing catches for 2013 to 2018 are shown on Figure 8.1-15. The data indicate a declining trend for artisanal finfish, prawn, and seabob shrimp catches in recent years, although the recent decline follows an increasing trend for 2010 through 2012. In the last decade, the contribution of the fishing subsector to Guyana's national GDP peaked at $25.76 billion GYD ($128.8 million USD) in 2014 (3.3 percent of GDP at basic prices) and subsequently declined to $11.45 billion GYD ($57.5 million USD) in 2020 (1.1 percent of GDP at basic prices; Bank of Guyana 2021).



Source: Ministry of Agriculture 2018, EMC Personal Communication 4
Note: Whitebelly is a species of shrimp and is included in the artisanal shrimp fishery in Table 8.1-5.

Figure 8.1-15: Commercial Fisheries Catch Volumes, 2013–2018

Bycatch of endangered turtles, sharks, and rays as a result of fishing operations represents a recognized challenge for the industry and is the subject of increasing targeted study (Kolmann et al. 2017; Garstin and Oxenford 2018).

Prawns and Shrimp

Within the fishery sector, the prawn industry has been voluntarily scaled back in response to limited catches resulting from overfishing in previous years, with approximately 15 Guyanese-registered boats in operation in 2016. Prawn fishing boats operate from the coast out to about 73 meters (40 fathoms; ERM Personal Communication 2).

The industrial seabob shrimp sector continues to be an important commercial fishery, and industry leaders are currently in the process of applying for Marine Stewardship Council certification (an internationally recognized voluntary process used to assess and certify the sustainability of wild-capture marine and freshwater species). The seabob fleet currently operates under a voluntary management plan (the only fishery-specific management plan for fisheries operating in Guyana's territorial waters) (ERM Personal Communication 2). The season for seabob production typically lasts for approximately 6 weeks, although if production is low, it can be extended for up to 10 weeks. In 2020, the seabob fishery was extended to 8 weeks (ERM Personal Communication 21).

Fishing Livelihoods

In Region 1, fishing is important for subsistence across most villages, as well as for small-scale commercial sale where there is access to markets. At the indigenous villages of Smith's Creek and Waramuri in Region 1, where the principal livelihood activity is fishing, drift seines are used by most fisherfolk, but longline and pole seines are also used. In 2018, fisherfolk from Smith's Creek reported spending approximately 5 to 6 days per week fishing in the Waini Region. Fisherfolk from Waramuri use fishing grounds in several locations in Region 1 and 2, including Kamwatta, Moruca River mouth, Pomeroon River mouth, Iron Punt, Charo Beach, and Danfore, spending up to 14 days at sea for each fishing trip. Fisherfolk from Waramuri dry/smoke fish during fishing trips since ice is unavailable for cold storage. Boats will usually dock at beaches along the coastline daily where this is done (EMC/ERM 2020).

Fishing is also important to all of the coastal NDCs in Regions 2 through 6, providing direct employment and income for numerous fisherfolk and indirect employment for numerous others in supporting services. As evidenced through research conducted in 2018 and 2019, the importance of fishing to local communities as well as the scale of fishing activities varies across regions. For example, one of the largest landing sites in Region 6 is Complex 66, where up to 200 vessels land during peak fishing seasons; a typical small landing site, like Rose Hall in Region 6, may only have four vessels which operate routinely (EMC/ERM 2020). Table 8.1-6 provides information on the estimated size of the vessel fleets at various coastal landing sites across Regions 1 through 6. These sites were selected as they provide a good representation of the entire coastline.

Table 8.1-6: Estimated Size of Artisanal Vessel Fleet at Selected Coastal Ports

Region	Port	Approximate Number of Vessels During Peak Season
Region 1	Smith's Creek	6
	Waramuri	20
Region 2	Charity	100
	Hampton Court	15
	Lima	30
Region 3	Zeeburg	30
	Windsor Forest	12
	La Grange	8
Region 4	Ogle	30
	Riverview (Unity)	30
Region 5	Mahaicony Bridge	15
	Rosignol	40
	Bushlot	40
Region 6	Rose Hall	4
	Albion	70
	Complex 66	200

Source: EMC/ERM 2019

Drift seines and fyke nets (also referred to in Guyana as Chinese seines) are the most frequently used gear type. In general, small artisanal vessels, characterized by having engine sizes of less than 40 horsepower and using fyke nets, are used in daily fishing trips. Fishing tends to occur along the coastlines at “pens” located near landing sites; for example, one vessel exclusively using fyke nets at the Ogle landing site was reported to make daily trips to pens located between 2 and 4 kilometers (1.2 to 2.5 miles) offshore from the landing site. Other small artisanal vessels use drift seines. These vessels frequently make daily trips and focus on fishing along the coastline near respective landing sites, but may stay at sea for up to 8 days. For example, fishing vessels from the Hampton Court landing site (Region 2) travel along the Essequibo Coast, while vessels from the Bushlot landing site (Region 5) target the Region 5 coastline. Smaller vessels typically do not travel more than 12 kilometers (7.5 miles) from shore, where fishing occurs at depths ranging from 2 to 31 meters (6.6 to 101.7 feet) (EMC/ERM 2019).

Larger artisanal vessels that have engine sizes of greater than 40 horsepower travel greater distances and have fishing trips of longer durations. For example, most of the vessels at the Charity landing site (Region 2) spend approximately 18 days at sea per trip fishing along the Essequibo Coast, frequently traveling as far east as the Waini River in Region 1. Larger artisanal vessels at the Rosignol (Region 5) and Complex 66 (Region 6) landing sites travel along the coastlines of Regions 5 and 6; in addition, some vessels are also licensed to fish in Surinamese waters. Larger vessels are reported to travel up to 25 kilometers (15.5 miles) from shore with fishing at depths of up to 28 meters (91.9 feet).

Table 8.1-7 provides an overview of the commercial fishing communities identified as part of the late 2017 and early 2018 field work by the Consultant team.

Table 8.1-7: Estimated Size of Commercial Fishing Communities in Coastal Regions

Region	NDC Name	Fishing Community
Region 1	Morawhanna	3 boats/1 person
Region 2	Charity/Urasara	20 persons
Region 3	Wakenaam (island)	60 persons
Region 4	Georgetown City	20 boats
	Better Hope / La Bonne Intention	35 boats
	Enmore/Hope	20 boats
Region 5	Hamlet/Chance	30 boats
	Profit/Rising Sun	60 boats
	Bath/Woodley Park	12 boats
	Zeelust/Rosignol	175 boats
Region 6	Macedonia/Joppa	100 persons

Source: ERM/EMC 2018

Data obtained during informal engagement with fisherfolk in 2018 suggest that the economies of Regions 5 and 6 are generally more dependent on commercial fishing than those coastal NDCs in other regions (ERM/EMC 2018).

A large percentage of fish captured using artisanal methods is sold to third parties. Sale prices are subject to short-term fluctuations. According to the fisherfolk interviewed as part of the Liza Phase 1 post-permitting fish study, the price of fish is seasonally influenced. Interviewees commented that the prices generally decline during the rainy season due to higher catches and increased supply (ERM 2018). Table 8.1-8 summarizes common and average prices per pound of fish catch, for different catch species. Prices in 2018 are provided for reference, indicating that catch price for many species is significantly lower in 2021 compared to 2018; according to some community sources, this could be attributed to reduced spending power in communities as a result of economic slowdown during the COVID-19 pandemic.

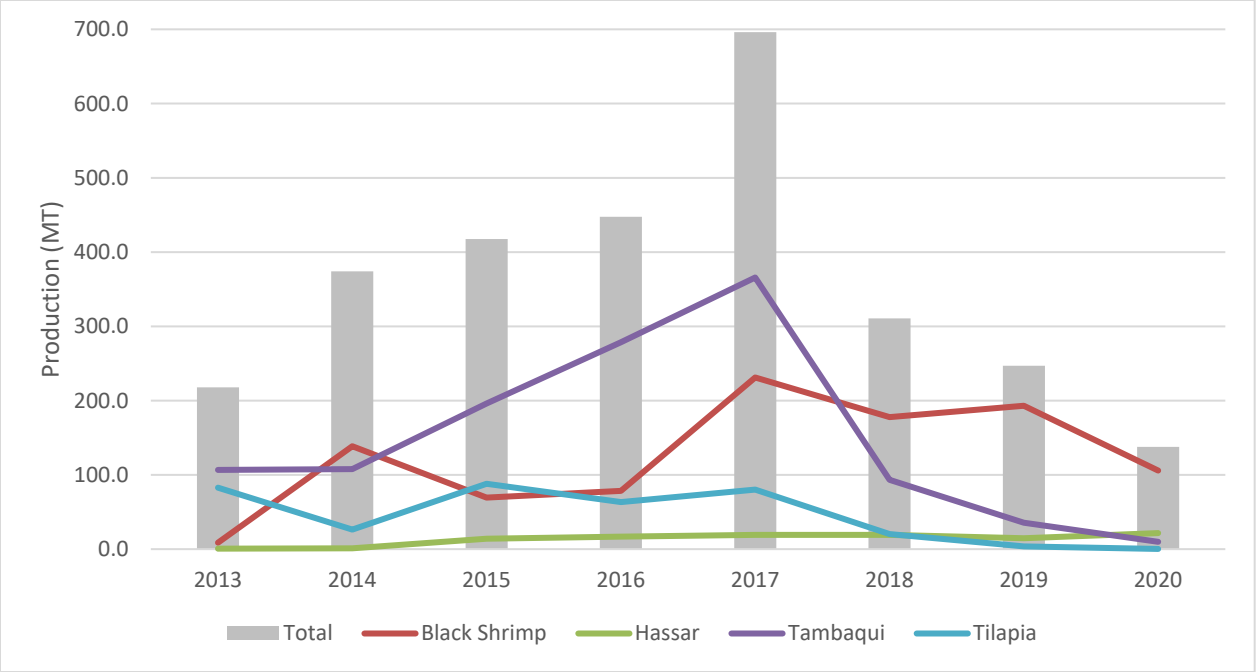
Table 8.1-8: Catch Price by Species

	2021			2018
Name of Species	**Average Price (GYD/lb)**	**Common Price (GYD/lb)**	**Range (GYD/lb) – estimated 2021**	**Range (GYD/lb) – estimated 2018**
Bangamary	107	100	100-200	200-300
Bangamary (fine)	70	90	80-100	-
Bashaw	114	100	100-200	-
Butterfish	128	140	100-200	200-400
Catfish	67	80	80-100	-
Cavalli	64	-	-	-
Cuffum	97	140	80-160	280-400
Cuirass	103	100	100-200	160-300
Gillbacker	376	380	300-400	500-2,000
Grey Snapper	282	340	200-380	250-800
Hammerhead Shark	146	-	-	-
Kukwari	43	-	-	-
King fish	146	160	100-200	-
Queriman	190	-	-	-
Pacu	148	-	-	200-300
Pagi	123	140	100-200	-
Highwaterman catfish	94	100	100-200	200-300
Mackerel	98	120	100-200	-
Shark	140	100	100-200	400
Seabob	330	400	300-400	100-500
Blacktip Shark	121	180	100-200	-
Snook	119	140	100-200	-
Whitebelly Shrimp	93	100	80-100	100-500
Suriname Mullet	155	160	100-180	-

Source: Ministry of Agriculture (2018, 2021c)
Note: "-" indicates data not available.

Aquaculture

According to data from the Ministry of Agriculture (2018, 2021c), the main species produced in aquaculture establishments are the bashaw, hassar, mullet, querriman, tambaqui, tilapia, and black shrimp. Although tilapia once dominated aquacultural yields, production has generally declined and been overtaken by yields of tambaqui and black shrimp. However, after a peak in 2017, overall aquaculture production has declined for all species since 2017. The total yield of aquaculture product between 2013 and 2020 is illustrated in Figure 8.1-16.



Source: Ministry of Agriculture 2018. 2021b

Figure 8.1-16: Fish Yields from Aquaculture, 2013–2020

According to the president of the National Aquaculture Association in 2016, aquaculture is still a small industry in Guyana and establishments are typically set up in abandoned rice fields. By using the same water supply and drainage configuration used for rice production, the aquaculture operations avoid dependency on brackish water and can raise freshwater species despite their coastal locations. Freshwater species being raised in rehabilitated rice fields include hassa, arapaima, tilapia, and tobaki (pacu) (ERM Personal Communication 16).

Although aquaculture is considered a small industry by the National Aquaculture Association, it was assessed by stakeholders as critical to livelihoods in many coastal NDCs throughout Regions 2 through 5 in 2018 (ERM/EMC 2018). At this time, the industry was most important to Regions 5 and 6, where it provided a livelihood for farmers. For example, in Bloomfield/Whim (Region 6) it was reported that six crabs could be sold for $500 GYD ($2.5 USD) in-season, while one bucket of shrimp could be sold for $10,000 GYD ($50 USD). Though impacted by the May to August 2021 floods, aquaculture production remained consistent in all regions and an important livelihood for some persons in the communities.

Mining and Quarrying

The mining and quarrying sector (excluding “petroleum, gas and related support services,” described separately) is an important sector for Guyana and has accounted for approximately 13 to 15 percent of national GDP in recent years (2017 to 2020; Bank of Guyana 2021). In 2020, faced with the challenges of operating during the COVID-19 pandemic, this sector contributed $128.8 billion GYD ($640 million USD) to GDP at basic prices (12.2 percent of

GDP), representing a decline from $142.7 billion GYD ($713.5 million USD; 14.8 percent of GDP) in 2019. Mining and quarrying products include gold, bauxite, diamonds, and stone.

The mining sector contributed more than 40 percent of exports in 2020. Most notably, raw gold, and bauxite equated to 37.8 percent, and 2.8 percent, respectively, of export totals in 2020 (BSG 2021). This represented a reduction of 26.9 percent compared with 2019 due to lower production of bauxite, gold, and diamonds. This decline was due to a decrease in the export volume which outweighed a rise in the export price (Bank of Guyana 2021).

The mining sector employs between 12,000 to 18,000 persons, which accounts for 4 to 6 percent of the total labor force (GOINVEST 2021).

Mining in Guyana was severely impacted by the May 2021 floods. Region 7 is the small- and medium-scale gold mining capital of Guyana and was financially impacted because of flooding effects. Mining ceased as mines were flooded and the multiplier effects of the activity dwindled (Kaiteur News 2021). In July 2021, President Ali stated that over 50 percent of mining operations were affected with mining areas cut off due to infrastructural damages, estimating that lost production amounted to approximately $23 billion GYD ($115 million USD) and $1 billion GYD ($5 million USD) in damages to mining infrastructure (Kaiteur News 2021).

Wholesale and Retail Trade

Wholesale and retail trade fell by approximately 29 percent in 2020. According to the Bank of Guyana, the combined impacts of reduced import levels for consumer goods (-11.9 percent) and the precautionary measures implemented by the Guyana National COVID-19 Task Force to address the spread of the coronavirus by restricting non-essential business activity were responsible for the significant decline in this sector (Bank of Guyana 2021).

The COVID-19 pandemic in 2020 and 2021 is reported to have had a significant impact on local businesses and commerce in Region 1 communities, with prices for food and basic commodities increasing while local residents' income and purchasing power have declined. Local shops and businesses have also closed, reducing supply. As reported during engagement with Region 1 communities in 2021, these changes have affected the ability of many households to access necessary food and supplies, and increased food insecurity. As a result, many families report having to access savings and/or loans in order to subsist since the start of the pandemic.

Manufacturing

The manufacturing sector recorded weakened output of 8.6 percent due to contractions of 3.7 percent, 5.7 percent, and 10.8 percent, respectively, in the sugar processing, rice milling and other manufacturing subsectors in 2020 (Bank of Guyana 2021). The most important manufactured products in terms of volume continued to include laundry soap, detergent, paints, putty, whitewash, oxygen, and acetylene, as well as edible goods including rice, sugar, and rum (PSC 2015). Guyana's manufacturing sector also benefited from increased demand as a result of the COVID-19 pandemic, most notably for the country's production of plastic sinks, pharmaceuticals, tablets, nitrogen gas, oxygen, and detergents (Bank of Guyana 2021). Many of the country's manufacturing facilities are located in coastal areas (ECLAC 2005).

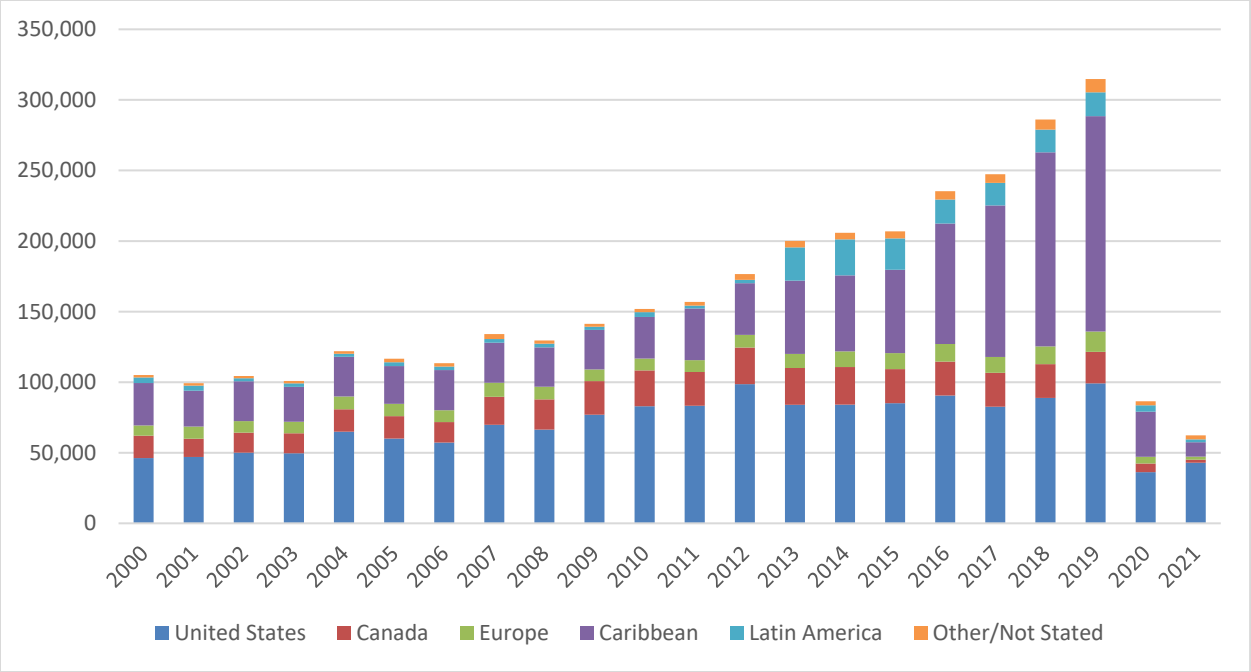
Tourism

According to the World Travel & Tourism Council (2021), tourism directly contributed 10.4 percent of the country's GDP in 2019, although this declined to only 5.5 percent in 2020 during the COVID-19 pandemic. Although most tourism infrastructure (e.g., hotels) is located in the more populated townships such as Georgetown, Linden, and Berbice, many of Guyana's tourist attractions are located in the country's hinterland. These attractions offer nature, culture, and adventure-based experiences such as trips to waterfalls and Amerindian villages. These trips range from same-day to multiple-night excursions. In 2020 and 2021, the COVID-19 pandemic has had a significant impact on tourism in Guyana, as in other parts of the world. In Region 1, community-based tourism is reported to have largely stopped during the pandemic, although some communities have embraced this period as an opportunity to implement new projects and facilities intended to support the local tourism industry.

Guyana is not a popular destination for cruise ships and receives only a few small ships each year. The country does not have the berthing capacity for large cruise ships (ERM Personal Communication 3).

Sediment deposition from the mouth of the Amazon River along Guyana's coast means that there are few beach offerings for tourists. The highly turbid water along the coast also likely contributes to the relatively small numbers of tourists that visit Guyana relative to other locations in the region with clearer water. Some tourism occurs at the Shell Beach Protected Area (SBPA) during the marine turtle nesting season, but this is limited because infrastructure and systems have not yet been established to facilitate travel or provide convenient accommodations. In general, however, Guyana is thought to have considerable ecotourism potential, and development of tourism infrastructure at the country's protected areas, including SBPA in Region 1, is considered a key part of the Protected Areas Commission's current strategic plan (PAC 2014).

Data from the Guyana Tourism Authority (2021) indicate that the number of international visitors to Guyana had tripled since the early 2000s, prior to the onset of the COVID-19 pandemic and related travel restrictions in 2020 and 2021 (see Figure 8.1-17). Between 2015 and 2019, the number of international visitors increased by 34 percent overall (Guyana Tourism Authority 2021). The largest number of visitors originates from the United States and the Caribbean, with smaller numbers from Canada, Europe, and Central and South America.



Source: Guyana Tourism Authority 2021
Note: 2021 data includes arrivals in January through June 2021.

Figure 8.1-17: Annual International Visitors to Guyana, 2000–2021

Before the COVID-19 pandemic suspended tourism in the country, the majority of visitors consisted of Guyanese expatriates returning to visit family; visitor numbers therefore peaked during the summer vacation (July and August) and key holidays (e.g., Christmas in December). However, the Guyana Tourism Authority has been increasing its efforts to raise Guyana's profile as a nature- and adventure-based tourism destination. In 2018, these activities included the launch of a "Destination Guyana" website and a social media strategy (Guyana Tourism Authority 2018); hosting several tourism agency trips to familiarize tour guides with Guyana; and securing representation in core tourism markets such as the United States, Canada, the United Kingdom, and Germany (Ministry of Business 2019). In 2019, Guyana was awarded the "Best Ecotourism Destination" at the ITB Travel and Trade Show Berlin (Stabroek News 2019).

As with the tourism sector globally, the Guyanese industry was impacted by the global COVID-19 pandemic in 2020, resulting in a decline in both visitor numbers and revenue from the industry. More generally, according to representatives of the Department of Tourism, increases in tourism in recent years have been attributed to increased regional sporting tournaments in the Georgetown area, particularly cricket events, which have attracted visitors from across the Caribbean and internationally. During major events such as the Cricket World Cup, increased traffic congestion has been observed in the Georgetown area (ERM Personal Communication 3).

According to personnel from the Department of Tourism in 2019, the oil and gas sector may be a catalyst to Guyana's tourism sector. The discoveries of oil and gas have raised Guyana's profile internationally, increasing exposure in potential tourism markets and attracting

international events. Furthermore, tourism sector operators have anticipated increased business travel associated with the oil and gas sector, which has increased interest in upgrading existing services such as accommodations, and establishing new services such as flights on new or underserved routes (ERM/EMC Personal Communication 3).

Most of the major tourist attractions are located in Georgetown, such as museums, the zoo, parks, public gardens, and the Stabroek Market. Georgetown and surrounding areas are known for their many historic buildings, which date from the late eighteenth century through the mid-nineteenth century, when Guyana was first a Dutch colony and then an English colony (National Trust of Guyana 2018). Guided tours of Georgetown's historic buildings and sites are available, as are guided tours of the Essequibo River, the El Dorado Rum Factory, the Georgetown City Centre, and other attractions.

In 2019, the Department of Tourism reported a new *Development of Regional Tourism Bodies* project that aims to integrate regional and local authorities in tourism planning at the regional level. Regional initiatives will depend on the available resources, particularly beaches and waterfront infrastructure and development (ERM/EMC Personal Communication 3). Local tourism and recreation are important to the local economy in the coastal NDCs in Regions 2 through 6, including those outside Georgetown. Some regions are less dependent on tourism (e.g., Region 2), with their coastline and beaches being frequented by ten or fewer locals daily. Other regions have economies that are more established and well-linked to local tourism. Region 3 and 4, specifically Best/Klien/Pouderoyen and Haslington/Grove, respectively, are known for their eco-tourism, with diverse bird species and protected mangroves. Regions 5 and 6, on the other hand, have beaches or other recreational areas (e.g., horse tracks) frequented by hundreds weekly (ERM/EMC 2018).

Some NDCs are looking to invest in local tourism and expand its economic return. For example, Rose Hall Town Council (Region 6) has control over a long stretch of beach that is frequented daily by 20 to 50 persons and hundreds on weekends, and is seeking development of further tourism opportunities.

8.1.3. Impact Assessment—Socioeconomic Conditions

8.1.3.1. Relevant Project Activities and Potential Impacts

The Project will not have any direct impact on the administrative divisions, population distribution, or education systems described in Section 8.1.2, Existing Conditions—Socioeconomic Conditions; any influx of population to the Georgetown area for work would be small and thus would not result in any change in the overall population distribution. Therefore, this section focuses on assessment of potential Project impacts on economic conditions in the Project AOI. The potential impacts considered for planned Project activities include the following:

- Project-related revenue generation and increased tax revenues for the government, potentially resulting in increased government spending on social services and infrastructure;

- Potential increased local business activity and related employment as a result of Project procurement and employment;
- Potential increased Project worker spending levels; and
- Potential increased cost of living to citizens due to higher demand for goods and services.

Contributions to GDP and Tax Revenue Generation

The Project will contribute directly and positively to increased national revenues through a Production Sharing Agreement between the Government of Guyana and EEPGL. Guyana's first year as an oil-exporting nation in 2020 was marked by 43.5 percent growth in real GDP, although non-oil real GDP contracted 7.3 percent. As such, development of the oil and gas sector represents a critical point in Guyana's development trajectory, and the government has pledged to use funds accrued from the sector for development of the country's infrastructure, including investments in health, education, agriculture, and power for domestic and industrial use (in alignment with Guyana's Green State Development Strategy) (DPI Guyana 2018; Oil Now Guyana 2018).

Employment and Business Activity

The economy will benefit from the Project through local procurement of select goods and services, limited direct local employment, and spending in local communities by Project workers. As of the first half of 2021, the total workforce supporting EEPGL's activities (including direct employees and contractors) amounted to more than 5,400, more than half of whom (more than 2,800 workers, or 53 percent of total) are Guyanese. The number of Guyanese workers has increased by 35 percent since June 2020, and has more than doubled since 2019 (2,126 and 1,183 Guyanese nationals, respectively). Roles held by Guyanese employees cover a range of skill levels and professions, including but not limited to entry level positions, apprentices, equipment operators, administrators, skilled trades, supervisors, professional personnel (e.g., engineers, lawyers, scientists), and managerial staff.

Notable milestones for EEPGL in 2020 included the commissioning of Liza Destiny, progression of Liza Phase 2, and approval of the Payara Development Project. Including the development of the Yellowtail Development Project, modest increases in total employment, including an increase of EEPGL's office staff (for all EEPGL activities), are expected, and EEPGL intends to continue hiring Guyanese nationals to the extent reasonably practicable in alignment with its Local Content Plan, which outlines EEPGL's strategy and multi-tiered approach to building Guyanese workforce and supplier capabilities in conjunction with strategic investments in the local community.

The creation of employment opportunities for residents of Guyana will contribute positively to economic conditions by generating income taxes, increasing household purchasing power, and generating increased sales tax revenue. In terms of local procurement, the majority of EEPGL's (and subcontractors') suppliers supporting in-country work scopes are Guyanese-owned (752 unique Guyanese-owned companies used in the first half of 2021, compared to 617 in the same period of 2020) and CARICOM-owned (102 companies). Over the course of 2020,

EEPGL engaged 806 unique Guyanese businesses. Business with Guyanese-owned suppliers amounted to $31.9 billion GYD ($159.5 million USD) over 2020, increased from $24.3 billion GYD ($121.6 million USD) in 2019. In the first half of 2021, the spend with Guyanese-owned businesses amounted to $14.8 billion GYD ($74.1 million USD). As part of the Yellowtail Development Project, EEPGL intends to continue procuring select Project goods and services from Guyanese businesses to the extent reasonably practicable.

As part of its efforts to optimize local content during prior development projects, including the Liza Phase 1 and Liza Phase 2 Development Projects, EEPGL and its contractors have implemented a range of training programs for workforce and local business-capacity building. In 2020, EEPGL provided more than 168,000 hours of training Guyanese staff, more than 70 percent of which was in the areas of professional, technical, and trade/craft training. As of the end of June 2021, an additional 82,000 hours of training had been delivered, more than 80 percent of which covered professional, technical, and health and safety training. In addition, more than 2,600 local businesses benefited from tender notifications and support provided through the Centre for Local Business Development (CLBD), which aims to help local businesses become globally competitive. As of June 2021, the CLBD has mentored 10 Guyanese companies to be certified in ISO 9001, while an additional 10 are currently being mentored through the compliance process.

It is anticipated that, beyond direct employment and service to EEPGL and its contractors, these capacity-building efforts will contribute to improved employment and business opportunities for participants over the long term. Similarly, a range of government capacity-building programs on topics such as waste management, oil spill response, protective species observer training, marine turtle telemetry and tracking, gas and power, energy literacy, local content, etc., have been conducted as part of the Liza Phase 1, Liza Phase 2, and Payara Development Projects, and these should contribute to enhanced administrative efficiency that will further facilitate business activity in Guyana. As part of the Yellowtail Development Project, EEPGL intends to continue on the same course with its workforce development, supplier, and government capacity-building efforts. In addition to direct expenditures and employment, the Project will also likely generate induced economic benefits, as other non-Project-related businesses benefit from direct Project purchases. Worker spending and increased purchase power by locals with additional income will likely expand spending in the local area. This will generate more local value-added tax. These beneficial “multiplier” impacts will occur throughout the Project life.

Worker Spending and Cost of Living

Potential adverse impacts of the Project on economic conditions associated with planned Project activities could include potential cost of living increases due to a higher demand for some goods and services, either through direct Project procurement or through Project worker purchases (see Section 8.5, Social Infrastructure and Services, for potential impacts on social infrastructure and services, including potential impacts to cost of lodging). Additionally, increased competition for skilled workers and support services could result from EEPGL and its contractors’ hiring and procurement activities, and could present a potential adverse impact for other companies and sectors that may not be able to pay salaries comparable to those of the oil

and gas sector. With the expansion of job opportunities in the oil and gas sector, it is likely that other sectors and the economy overall will need to adjust to wider economic changes, which may include upward pressure on salaries.

While this may cause short-term challenges for other sectors, the long-term effects should be positive overall; Guyana is known for having a high level of "brain drain," whereby a large percentage of the tertiary-educated population emigrates from the country, mostly to Organisation for Economic Co-operation and Development nations (World Bank 2000; World Bank 2016; Guyana Chronicle 2015). Provided that a more robust employment environment can be demonstrated, an increase in high-skilled, high-paying jobs associated with the oil and gas sector should contribute to the attenuation of this phenomenon, creating a larger pool of advanced workers for all areas of the economy. EEPGL's ongoing capacity-building and training initiatives will remain attentive to the need to foster a more qualified workforce and to enhance the capacity of local suppliers to serve a larger and more diverse clientele, rather than focusing only on the immediate needs of the oil and gas sector.

Summary

Table 8.1-9 summarizes the Project stages and activities that could result in potential Project impacts on economic conditions, as well as the receptors that could potentially experience these impacts.

Table 8.1-9: Summary of Relevant Project Activities and Key Potential Impacts—Socioeconomic Conditions

Stage	Receptor(s)	Project Activity	Key Potential Impacts
All Project stages	Guyanese population—principally in the Georgetown Area	Project revenue generation	• Potential government investment in social services and economic development/diversification • Potential government infrastructure projects
		Project hiring and workforce training	• Direct hiring of Guyanese nationals for a limited number of positions • Hiring of Guyanese nationals by Project contractors and subcontractors • Increased experience, capacity and skills of local workers and subcontractors • Competition with other local businesses for qualified workers
		Project procurement of selected goods and services	• Increased sales tax revenues • Increased local business activity and growth • Increased demand for services and infrastructure,
		Project capacity building programs for prospective local suppliers	

Stage	Receptor(s)	Project Activity	Key Potential Impacts
		Project worker spending	potentially leading to increased cost of living and/or procurement challenges for other companies
		Limited local direct employment and increased opportunities through indirect employment	

8.1.3.2. Magnitude of Impact—Socioeconomic Conditions

The assessment of the Project's magnitude of potential adverse impacts on socioeconomic conditions is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on socioeconomic conditions (including economic changes related to cost of living) is defined in Table 8.1-10.

Table 8.1-10: Definitions for Intensity Ratings for Potential Impacts on Cost of Living and Competition

Criterion	Definition
Intensity	Negligible: The changes do not bring about a perceptible increase in cost of living or economic competition.
	Low: There is a small but perceptible increase in cost of living or economic competition for some individual households or businesses.
	Medium: Increased cost of living or economic competition is evident for receptors at the group, community, or sector level.
	High: Increased cost of living or economic competition is widespread and uncontrolled and results in chronic hardship for households and/or small and medium-size businesses.

Economic Benefits

The Project has the potential to impact economic conditions both positively and adversely. Project revenues to the national government through its Petroleum Agreement with EEPGL can allow for increased government spending on social infrastructure, services, and programs, as well as investment in infrastructure programs and different economic sectors. Economic conditions can also be impacted positively by local hiring for a limited number of new positions, local Project procurement, and Project worker spending.

Considering the factors above, potential economic benefits of the Project are expected to outweigh potential negative impacts such that overall impact on the economy is expected to be **Positive**. As described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, this assessment does not develop magnitude ratings for positive impacts.

Increased Cost of Living and Competition

Although the Project's local hiring and procurement will be overwhelmingly positive for the country, it could present challenges for other companies and sectors if it creates competition with other local businesses for workers, goods, and services. A potential adverse impact could therefore occur from increases in the cost of living due to competition for workers and higher demand for some goods and services. Given the Project's relatively small workforce (i.e., of the more than 5,400 direct and contractor workers supporting EEPGL's activities in the first quarter

of 2021, more than 2,800 were Guyanese, thus representing approximately 0.9 percent of the national labor force; BSG 2021) and predominantly offshore footprint, such increases are expected to be limited. However, the Project's demand for workers with specific types of skills and experience may disproportionately affect some categories of workers more than others.

As the oil and gas sector adds more jobs and increased demand for workers and services exerts upward pressure on salaries in some sectors, it is expected that the availability of a more robust and high-paying employment situation will contribute to reduced emigration of tertiary educated and otherwise qualified workers from the country. This should provide a more qualified workforce for all sectors of the economy over the medium to long term.

Considering the factors above, a potential adverse effect on cost of living and economic competition is expected to be limited to the **Direct AOI**. Although oil-and-gas sector activity has seen rapid growth in in recent years, there is little evidence of changes in cost of living other than anecdotal accounts (although the COVID-19 pandemic and other external factors have led to increased food and commodity prices in Region 1 and other areas). As the Guyanese economy continues to evolve, there could be a future perceptible increase in prices and competition for workers for some receptors, although the contribution of the Yellowtail Project is expected to be a small part of this change. As the change is not expected to be evident across communities or sectors, the intensity of the potential impact is rated as **Low**. Project-related salaries and economic activity will occur throughout the Project life cycle (at least 20 years), yielding a frequency designation of **Continuous** for all stages and a duration of **Long-term**. This yields a magnitude rating of **Small** for potential impacts on cost of living and economic competition (see Table 8.1-11).

Table 8.1-11: Magnitude of Impact—Cost of Living and Competition

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
All Project Stages	Guyanese population including lower income subpopulation (in particular Georgetown population) - potential for increased cost of living, potential for competition with other local businesses for qualified workers	Direct AOI (Georgetown and vicinity)	Low	Continuous	Long term	Small

8.1.3.3. Sensitivity of Receptors—Socioeconomic Conditions

The receptors with the potential to be affected by potential impacts on economic conditions include the full Guyana population, but those most likely to be potentially impacted are residents in the Georgetown area. As discussed below, vulnerable (lower-income) populations are considered to be more sensitive to these potential impacts and are therefore considered separately. The receptor sensitivity ratings for economic conditions are defined in Table 8.1-12.

Table 8.1-12: Definitions for Receptor Sensitivity for Potential Impacts on Socioeconomic Conditions

Criterion	Definition
Sensitivity	Low: The local and regional economies are highly diversified and not highly dependent on any one sector. The workforce is highly skilled, would not experience major challenges in shifting to different occupations, and is well positioned to benefit from the Project.
	Medium: The local and regional economies are somewhat diverse and dependent on a few key industrial sectors that are not all natural resources-based. Alternate economic opportunities, including from the Project, are possible, but the workforce may require additional training to be able to pursue such opportunities.
	High: The local and regional economies are highly dependent on one or a few industrial sectors that are largely natural resources-based. There are few alternate economic opportunities in the area and/or the workforce does not have the skills to shift to pursue alternate economic opportunities.

Receptors in the Georgetown area (Region 4) are considered to have a **Low** level of sensitivity to economic impacts, given their ability to benefit from the Project and the associated business opportunities, and since the economy in this region is relatively diverse and less dependent on natural resources than in other areas of the country, with 12 percent of jobs in the primary sector, 21 percent in the secondary sector, and 67 percent in the tertiary sector[6].

Within the Georgetown area, some individuals and households of lower socioeconomic status are considered to have a **Medium** level of sensitivity to economic impacts due to their lower capacity to benefit from the Project and the business opportunities it may bring, and to their higher level of vulnerability to an increased cost of living. However, this vulnerable population will stand to benefit from increased government revenues along with the general population, should such government revenues be invested in social infrastructure, services, and programs, as well as investment in infrastructure programs and different economic sectors.

8.1.3.4. Impact Significance—Socioeconomic Conditions

Based on the discussion above, the potential impacts on economic conditions are rated as **Positive** overall for both the general population and the low-income subpopulation, with potential impacts on receptors in the Georgetown area likely to be more highly impacted (i.e., benefitted). As described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, this assessment does not develop significance ratings for positive impacts.

Considering the potential impact of increased cost of living and/or competition for skilled labor, the potential impacts (if they occur) are expected to be centralized on the population in the Georgetown area. Based on the magnitude of impact and the receptor sensitivity ratings, the significance of potential adverse economic impacts on the general population of the

[6] According to the Bureau of Statistics Guyana (BSG 2002) (the most recent dataset broken down at the city level), the primary industrial sectors (e.g., agriculture, fishing, forestry, and mining) make direct use of natural resources and include the production of raw materials and basic foods. The secondary sector is engaged in manufacturing using raw products from the primary sector and includes processing, construction, textile production, brewing and bottling, etc. The tertiary sector provides services to the general population and businesses, including retail and wholesale trade, transportation and distribution, entertainment, tourism, healthcare, etc.

Georgetown area is rated as **Negligible**, while the potential significance for the low-income population (with a higher sensitivity to change) is rated as **Minor**.

8.1.4. Management Measures—Socioeconomic Conditions

As the expected potential impact on economic conditions is net positive, no mitigation measures are required. However, to enhance the benefits from this positive impact, the Project intends to continue its current local hiring and procurement practices, with ongoing capacity-building initiatives to optimize local content to the extent practicable. Table 8.1-13 summarizes the embedded controls and monitoring measures relevant to this receptor.

Table 8.1-13: List of Embedded Controls, Mitigation and Monitoring Measures

Embedded Controls
Employ Guyanese citizens having the appropriate qualifications and experience where reasonably practicable.
Partner with select local institutions and agencies to support workforce development programs targeted to in-demand skillsets, and proactively message Project-related employment opportunities.
Procure Project goods and services locally when available on a timely basis and when they meet minimum standards and are commercially competitive.
Mitigation Measures
Proactively communicate the Project's limited staffing requirements as a measure to reduce the magnitude of potential population influx to Georgetown from job seekers.
Monitoring Measures
Monitor percentage of Project Workforce made up of Guyanese nationals on a quarterly basis.
Monitor percentage of Project goods and services expenditures procured locally on a quarterly basis.

Table 8.1-14 summarizes the assessment of potential pre-mitigation and residual Project impacts on socioeconomic conditions. The significance of impacts was assessed based on the general impact assessment methodology described in Chapter 4.

EEPGL recognizes that potential population influx and potential competition for skilled workers could both influence cost of living in the Georgetown area. Efforts to communicate hiring and staffing requirements to reduce population influx should serve to minimize potential increases in cost of living within Georgetown and the surrounding area. In the long term, EEPGL's workforce development programs will reduce competition for workers by developing a base of skilled workers (a benefit for the Guyana labor force overall). Given the pace of economic change and its link to oil-and-gas development, the significance of potential impacts is maintained at a rating of **Negligible** for the general population of the Georgetown area, and **Minor** for the area's low-income population.

While potential impacts include both adverse and positive changes, the overall potential impact on socioeconomic conditions is expected to be (net) positive.

Table 8.1-14: Summary of Potential Pre-Mitigation and Residual Impacts—Socioeconomic Conditions

Stage	Potential Receptor Impact	Magnitude			Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	Guyanese population including lower income subpopulation (in particular Georgetown population) - increased government revenues, increased employment, increased local business activity	Not rated (Positive) [a]			Low (general population) Moderate (lower income groups)	Positive [a]	None	Positive [a]
All Project stages	Guyanese population including lower income subpopulation (in particular Georgetown population) - potential for increased cost of living, potential for competition with other local businesses for qualified workers	Small			Low (general population) Moderate (lower income groups)	Negligible (general population) Minor (lower income groups)	Proactive messaging regarding Project employment opportunities	Negligible (general population) Minor (lower income groups)

[a] While some of the identified potential impacts are adverse and some are positive, the overall potential impact on socioeconomic conditions is expected to be (net) positive.

8.2. EMPLOYMENT AND LIVELIHOODS

8.2.1. Administrative Framework—Employment and Livelihoods

Table 8.2-1 summarizes the legislation, policies, or treaty commitments that are specifically relevant to the assessment of potential impacts on employment and livelihoods.

Table 8.2-1: Legislation, Policies, or Treaty Commitments—Employment and Livelihoods

Title	Objective	Relevance to the Project
Legislation		
Occupational Safety and Health Act (1997) Cap. 99:06.	Legally defines the responsibilities of workers and management with respect to keeping workplaces safe.	Generally applies to Project workers and Project-related activities.
Food and Drug Regulations (Food and Drug Act, 1971) Cap. 34:03.	Regulates the sale, advertisement, preparation, and handling of food products; regulates the manufacture, advertisement, trade, and administration of pharmaceuticals; provides the Ministry of Health authority to inspect facilities to establish compliance with sanitation standards.	Governs the preparation of food and provision of medications at Project facilities.
Prevention of Discrimination Act (1997) Cap. 99:08.	Provides for the elimination of discrimination in employment, training, recruitment, and membership in professional bodies and the promotion or equal remuneration to men and women in employment who perform work of equal value.	Prevents discrimination in employment practices.
National Insurance and Social Security Act (1969) Cap. 36:01.	Establishes a system of national insurance and social security providing pecuniary payments by way of old age benefit, invalidity benefit, survivor's benefit, sickness benefit, maternity benefit, and funeral benefit, and to substitute for compensation system of insurance against injury or death caused by accident arising in the course of employment or resulting from disease due to the nature of employment; establishes a National Insurance Fund.	Provides the overarching framework for workers' insurance and other benefits.
Employment of Young Persons and Children Act. Cap. 99:01.	Seeks to implement certain conventions relating to the employment of young persons and children.	Restricts the ages of young persons who may be employed by the Project.
Termination of Employment and Severance Pay Act (1997, 1999) Cap. 96:01.	Makes provision for the conditions governing termination of employment and grant of redundancy or severance payment to employees.	Governs payments to employees or the termination of employment. This could be relevant to contractors and sub-contractors to the Project.

Title	Objective	Relevance to the Project
Local Content Act (2021)	Provides for the implementation of local content obligations for petroleum operations or related activities in the petroleum sector.	Directly influences Guyanese service provision and employment in the petroleum sector. Includes requirements to develop and submit local content plans, as well as auditing and reporting. Also establishes an official register of Guyanese nationals and Guyanese companies for employment and procurement and provides detailed annual local content targets for certain sectors and sub-sectors. Establishes a Local Content Advisory Committee to provide recommendations and collaborate on strategic initiatives related to local content.
Policies		
Occupational Safety and Health Policy (GoG 2018)	Aims to promote and improve the quality of life of workers by preventing social and economic losses, work-related accidents, and injury to health by eliminating hazards, reducing the number of accidents, and injuries, and combating stresses and incidence of occupational diseases. The policy orients the Ministry of Social Protection to modernize its policies and procedures. Implementation is supported by the International Labour Organization.	Applies to all categories of workers and workplaces, in all sectors, including the Project and Project workers.

8.2.2. Existing Conditions—Employment and Livelihoods

8.2.2.1. National Characteristics

The most recent iteration of the Guyana Labour Force Survey provides data for the first quarter of 2021 (BSG 2021). Results indicate that as of the first quarter of 2021, the unemployment rate was 15.6 percent (46,480 persons), compared to 12.8 percent, 13.4 percent, and 14.7 percent in the same quarter in 2020, 2019, and 2018 respectively (BSG 2020b, 2020a, 2019). As of the first quarter of 2021, Guyana's working-age population (aged 15 and above) was 581,594 persons, of which approximately 72.1 percent were based in rural areas. Women accounted for 52.5 percent and men represented approximately 47.5 percent of the working-age population. However, men represented 60.3 percent of the total labor force.[7]

Among the working-age population, participation in the labor force[8] was higher among men than women (64.9 percent versus 38.7 percent), and slightly higher in urban areas (53.2 percent)

[7] The labor force is defined as the sum of employed persons and unemployed persons.
[8] The labor force participation rate is defined as a percentage of the working age population.

compared to rural areas (50.3 percent). The employment-to-population ratio was 43.2 percent, with a significant difference between the rate of men (56.3 percent) and women (31.3 percent) (BSG 2021).[9] In the first quarter of 2021, approximately 35.9 percent of youth (aged 15 to 24) were not in education, employment, or training; this percentage has been relatively consistent since data reporting began in 2017 (BSG 2018a,b, 2019, 2020a,b, 2021).

The private sector accounts for 65 percent of employment, with the public sector and not-for-profit organizations accounting for 23 percent and 12 percent, respectively. A larger share of women than men is employed in the public sector. As of the first quarter of 2021, the majority of employed persons work in either the wholesale and retail trade sector (16.0 percent), or the public administration and defense sector (13.4 percent). Recent growth in the public administration and defense sector has been offset by a 35 percent decrease in employment in agriculture, forestry, and fishing, which has dropped from the largest single employment sector to the third largest employment sector in Guyana's economy since 2017. Table 8.2-2 presents employment in Guyana by economic sector for 2012 compared to results from the final quarter of 2017 (BSG 2018b) and the first quarter of 2021 (BSG 2021). This data is based on International Standard Industrial Classification, wherein oil and gas activities are captured under the "mining and quarrying" sector.

Table 8.2-2: Employment in Guyana by Economic Sector in 2012, 2017, and 2021

Economic Sectors	2012	2017 [a]	2021 [b]
Agriculture, forestry, and fishing	17.5	18.9	12.2
Wholesale and retail trade	15.4	16.1	16.0
Public administration and defense	7.2	9.3	13.4
Construction	10.4	7.7	10.2
Manufacturing	8.6	8.4	10.1
Transportation and storage	7.7	7.3	6.9
Education	5.3	6.3	4.2
Mining and quarrying	8.2	4.2	4.6
Administrative and support services	3.7	4.3	5.0
Accommodation and food service activities	2.8	4.4	5.1
Human health and social work activities	2.7	1.2	0.8
Activities of households as employers	2.3	2.8	3.4
Other service activities	2.7	2.6	3.3
Financial and insurance activities	1.3	1.2	1.0
Professional, scientific, and technical services	1	0.97	1.1
Water supply, sewerage, and waste management	0.5	1.24	0.6
Information and communication	1	0.84	1.0
Electricity, gas, steam, and air conditioning	1	0.82	0.6
Activities of extraterritorial organizations	0.2	0.8	0.1
Arts, entertainment, and recreation (not statistically significant)	0.6	0.5	0.5

[9] The employment-to-population ratio is defined as the proportion of a country's working age population that is employed.

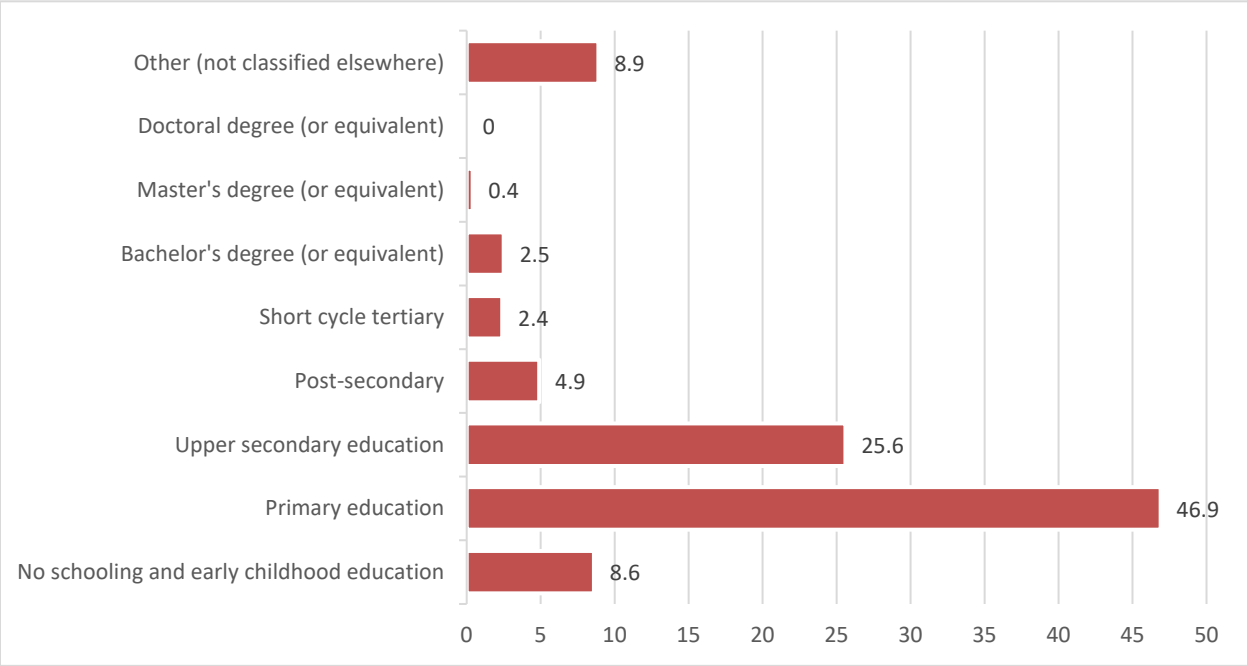
Economic Sectors	2012	2017 [a]	2021 [b]
Real estate activities (not statistically significant)	0.1	<0.1	0.1
Not classifiable by economic activity	0.3	<0.1	<0.1

Source: BSG 2016, 2018b, 2021

[a] Results from the Guyana Labour Force Survey for the final quarter of 2017
[b] Results from the Guyana Labour Force Survey for the first quarter of 2021

Approximately 48.2 percent of workers in the first quarter of 2021 are informally employed. Of this total, approximately 54 percent are men and 39 percent are women; and approximately 51 percent identified as rural residents, and 41 percent as urban residents (BSG 2021).[10] Informal employment is characterized by a low level of organization, and labor relations have no contractual arrangements or formal guarantees (BSG 2018b).

Approximately 25.6 percent of Guyana's working-age population has attained secondary education, and post-secondary and higher levels of study are less prevalent (BSG 2021), as shown on Figure 8.2-1. More than half of the population nationally has attained primary education or little/no formalized schooling.



Source: BSG 2021

Note: Results for 'Masters or equivalent' and 'Doctoral or equivalent' categories were not considered statistically significant.

Figure 8.2-1: Percentage Share of Working Age Population by Education Completed, First Quarter 2021

[10] Source data do not add to 100 percent. Coefficient of variation for informal worker statistics ranges from 2.62 percent to 5.35 percent (BSG 2021).

Recent Developments

Guyana's GDP grew by 43.5 percent in 2020, up from 5.4 percent annual growth in 2019 and a recent low of 0.7 percent growth in 2015 (BSG 2021; IMF 2021). The remarkable growth in GDP is attributed to the energy industry, as 2020 was the country's first year as an oil-producing nation[11]. More information about the impact of the energy industry on national GDP and tax revenues is provided in Section 8.1, Socioeconomic Conditions.

Publicly available statistics do not yet reflect the impact of this shift on the Guyanese labor force and related statistics. However, 56 percent of the workforce supporting EEPGL's activities[12] were Guyanese in the first quarter of 2021, with a total of 2,604 Guyanese workers; the number of Guyanese workers has more than doubled from 1,183 in 2019. In addition, in the first quarter of 2021, activities were supported by 614 Guyanese vendors with a total spend of $9.15 billion GYD ($45.8 million USD) directly through contracts with Guyanese companies. The jobs generated by these activities cover a range of the economic sectors listed in Table 8.2-2, and may contribute to the reduced role of agriculture, fishing, and forestry, relative to other sectors, as a proportion of employment in 2021 (BSG 2021).

The development of the global COVID-19 pandemic in 2020 has also affected employment and livelihoods across Guyana. A May 2020 study of the pandemic's impacts on food security and livelihoods in Guyana reported that 77 percent of respondents indicated that their livelihoods were negatively affected, as a result of factors such as movement restrictions, transportation constraints, health concerns, reduced demand for goods and services, and loss of livelihood inputs (WFP 2020). Thirty-eight percent of respondents indicated that they experienced lost jobs or reduced salaries, while 8 percent reported that they had resorted to alternative means to maintain their income or livelihood. The study also identified a need to examine potential impacts of the COVID-19 pandemic on people engaged in agricultural and fishing/coastal livelihoods (WFP 2020).

8.2.2.2. Regional Characteristics

The most recent employment data available by region are from the 2012 national census (BSG 2016), which found that the Region 1 unemployment rate was the highest in the country, at 19.3 percent of the labor force. Region 2 had the lowest unemployment rate, at 10.6 percent. Regions 3 and 4 had rates of 11.8 percent and 11.3 percent, respectively. The next national census is planned in 2022.

Statistics from the 2012 census indicate the following employment percentages for workers 15 years of age or older in the agriculture, forestry, and fishing sector: 23.0 percent in Region 1, 27.9 percent in Region 2, and 18.8 percent in Region 3 (BSG 2016). This sector employed the largest number of workers in Regions 2 and 3; in Region 1, the sector was second to mining and quarrying. The mining and quarrying sector employed the second largest group in Region 2

[11] As reported by the Bank of Guyana's 2020 Annual Report, the national economy registered real oil GDP growth of 43.5 percent (compared with 5.4 percent growth in 2019), as the sector recorded its first full year of oil production. In the same period, real non-oil GDP contracted by 7.3 percent (compared with a growth of 4.3 percent in 2019), due to the adverse effects of the COVID-19 pandemic and political uncertainty (BSG 2021).
[12] Including production of Liza 1, and progress of the Liza 2 and Payara development projects

(14.9 percent), while in Region 3, the construction sector employed the second largest group (12.1 percent). In general, the primary sector industries in these regions[13] are dominated by male workers, with female workers making up less than 10 percent of the workers.

Census data show that tertiary (service) sector jobs such as wholesale and retail trade, public administration, and accommodation and food services are dominant in Region 4 (including Georgetown), making up 67 percent of jobs. Female representation in this sector is high, with women making up 48 percent of workers (BSG 2016). Secondary and primary sector jobs make up 21 percent and 12 percent of employment, respectively, in Region 4.

Residents of hinterland regions, including Regions 1 and 2, are largely indigenous. The issues facing indigenous groups are typically related to lack of empowerment and inclusion into the mainstream economy, and the standard of living for the indigenous minority continues to be lower than for the majority of the country's citizens. A larger proportion of the Amerindian population is classified as socioeconomically disadvantaged (Minority Rights Group International 2018) due to a lack of employment opportunities in their villages and few persons with formal qualifications (UNICEF 2017). Income-generating opportunities in the indigenous coastal communities of Regions 1 and 2 are scarce and include heart of palm harvesting and the wildlife trade, including sale of aquarium fish (IDB 2007). Coastal fishing and subsistence farming are common (APA and FPP 2016). In the past, the Region 2 village of Mainstay operated an organic pineapple farm and processing facility; however, the plant was shut down several years ago (ERM Personal Communication 4). Some residents of indigenous communities in Regions 1 and 2, particularly men, also work in mining and logging camps in the hinterland (IDB 2007; APA and FPP 2016). Many of these men migrate from their villages for periods of a few weeks to a few months if no mining or logging camps are in the vicinity (UNICEF 2017).

Many of the residents in the coastal NDCs/CDCs or TCs in Regions 1 through 6 are directly employed by or linked to the fishing industry due to their proximity to the coast. For example, the primary provisioning service in all six regions is fishing, and fishing accounts for approximately 25 percent of the ecosystem services in the study area based on field assessments in these communities (ERM/EMC 2018; Appendix S, Enhanced Coastal Sensitivity Mapping—Ecosystem Services Final Report).

Similarly, fishing support services include boat building and repairs, fuel services, entertainment, and household products needed by sailors and fisherfolk—and these provide numerous employment opportunities to residents.

[13] According to the Bureau of Statistics Guyana, the primary sector industries (e.g., agriculture, fishing, forestry, and mining) make direct use of natural resources and include the production of raw materials and basic foods. The secondary sector is engaged in manufacturing using raw products from the primary sector and includes processing, construction, textile production, brewing and bottling, etc. The tertiary sector provides services to the general population and businesses, including retail and wholesale trade, transportation and distribution, entertainment, tourism, healthcare, etc.

Fishing

Fishing along the Guyanese coast varies in scale and type. In Region 1, a significant share of all fishing activity is artisanal, which is used for sustenance, although some villages collectively own “community boats” and use the catch for sustenance as well as commercial sale. There is only one formal landing site in Region 1 (Morawhanna) for vessels engaged in industrial-scale fishing activity (see Figure 8.2-2) and two landing sites with larger fish markets in Mabaruma and Santa Rosa. Artisanal fishing vessels from nearby communities frequently visit these three landing sites to sell their catch. Commercial species sold at these sites include bangamary, trout, cuirass,[14] snook, sea catfish, and gillbacker. Due to limited options for cold storage of catch, a significant amount of fish is dried or smoked before sale in Region 1 (Figure 8.2-3; Appendix D, Participatory Fishing Survey Final Report January 2019–March 2020).

Figure 8.2-2: Industrial-Scale Landing Site, Morawhanna, Region 1

[14] Presumed to be *Arius proops*

Figure 8.2-3: Salted Fish Drying Outside a Fisherfolk Home in Region 2

Most fisherfolk in Regions 2 through 6 are involved in artisanal fishing. Artisanal boats are still used because the coastal mudflats in these regions typically do not allow for the use of larger boats. Landing sites in these coastal regions vary in the size of their vessel fleets. As described in Section 8.1, Socioeconomic Conditions, one of the largest coastal landing sites is the Village 66 Complex in Region 6, with an artisanal fleet of 200 vessels during peak fishing seasons. Smaller landing sites with fewer vessels are found throughout the coast from Region 2 through 6, the most commonly known being Hampton Court (Region 2), Windsor Forest and La Grange (Region 3), Mahaicony Bridge (Region 5), and Rose Hall (Region 6) (see Section 8.4.2, Existing Conditions—Marine Use and Transportation).

Smaller artisanal vessels typically have crews of 1 to 3 persons per trip. Small artisanal vessels that use fyke nets (also referred to in Guyana as Chinese seines) or pin seines make daily trips. However, vessels using drift seines also make daily trips, but may stay at sea for up to 8 days. Fishing using small vessels is focused along the coastline near respective landing sites. Larger artisanal vessels that have engine sizes of greater than 40 horsepower travel greater distances and have fishing trips of longer durations. They also have larger crews of six to eight persons per trip. Larger artisanal vessels from landing sites in Rosignol (Region 5) and the Complex 66 (Region 6) are also licensed to fish in Surinamese waters. Vessels typically travel up to approximately 40 kilometers (24.8 miles) offshore, although this varies by region (EMC 2021).

Species caught by artisanal vessels in Regions 2 through 6 include whitebelly shrimp, seabob, gillbacker, trout, bangamary, butterfish,[15] cuirass, snook, sea catfish, cuffum, snapper, shark, and bashaw,[16] among others. Some fish are sold locally to ice trucks that visit the landing sites on a daily basis to purchase fresh catch from fisherfolk; other fish are sold in the villages. Some

[15] Presumed to be *Nebris microps*; the colloquial names “butterfish” and “butterhead” are used interchangeably for this species.
[16] Presumed to be *Micropogonias furnierei*

fisherfolk, such as those from the La Grange landing site (Region 3) and Riverview landing site (Region 4), visit the Meadowbank Wharf and others visit the Stabroek Market in Georgetown to sell their catch (Figure 8.2-4; ERM Personal Communications 14, 17, 18, and 19; Appendix D, Participatory Fishing Survey Final Report January 2019–March 2020). Fishing yields vary by season, with fisherfolk reporting the highest yields in June through September. From October to early February, catches are at their lowest due to seasonally colder waters coming from the north.

Figure 8.2-4: Fresh Fish Being Sold at Stabroek Market in Georgetown

Industrial fishing operators in Guyana are based mainly in Region 4 and have private wharfs where their vessels dock. The industrial vessels largely target seabob and prawns, but also catch red snapper, shark, and tuna. The deepwater tuna fleet is currently at 12 vessels (ERM/EMC Personal Communication 4; ERM Personal Communication 24).

Several NDCs in Region 6 reported that boats from their communities are increasingly docking in Suriname instead of Guyana. They reported that the amount of fishing activity and the number of boats remain the same. This was especially the case in Number 55 Village where, of the 400 boats, more than 40 were now docking in Suriname (ERM Personal Communication 34). In 2021, a joint announcement by the presidents of Guyana and Suriname reported that, beginning in January 2022, six Surinamese fishing licenses will be granted to Guyanese fisherfolk (Chabrol 2021).

Participatory Fish Study Results

EEPGL has implemented the Participatory Fish Study, in collaboration with local consultants, since 2017. The first phase of the study ended in March 2020, and a second phase began in March 2021 with the intent of building on the existing knowledge base. The study has researched artisanal fishing including information and patterns in gear type, target species,

fishing grounds, and other factors. In relation to changes in fishing activities since the beginning of the COVID-19 pandemic, the June 2021 Participatory Fishing Study report indicates that:

- Public health and travel restrictions prevent fishing along the Surinamese coastline, which was previously targeted by some fisherfolk from Region 6.
- The nationwide curfew hindered normal fishing activities by limiting fishing trips that would normally occur early in the morning or late at night. At some locations, this resulted in changes in fishing grounds; this was particularly evident in records of fishing grounds near Mahaicony in Region 5.

In addition, persistent heavy rainfalls during the 2021 floods also affected shrimping activities by increasing freshwater loads. In Region 3 and Region 4, fisherfolk changed fishing grounds in search of productive areas. In other regions, fishing methods and gear were adjusted. Due to the high cost of fuel, some locations reported longer fishing trips in an attempt to maximize haul and reduce fuel consumption. In other locations, changes in fishing locations in response to the high freshwater load led to reduced fishing effort and/or travel times.

Another trend identified in the most recent Participatory Fishing Study report is the high demand for snapper, which is valued for the high price of its glue (which can be worth approximately 50 times greater than the value of the flesh of the fish). Swim bladders and fish eggs also have relatively high value. Between April and June 2021, snapper was the most abundant fish caught at Smith's Creek and Charity landing sites. Snapper is an elusive fish and requires greater effort to catch, and as a target species, it can therefore impact overall fishing effort.

The COVID-19 pandemic significantly reduced the value of fish due to lower demand in both local and export markets. At most landing sites, prices have rebounded in 2021.

Other Challenges for the Fishing Industry

Prior to March 2020, when asked about changes in fishing yields over the years, responses from Region 2 artisanal fisherfolk varied, with most reporting no noticeable change in catch volume. However, an individual with a relatively large-scale operation of three boats operating out of Charity in 2018 stated that catches are declining and attributed this to an over-allocation of fishing licenses by the government (ERM Personal Communication 15). During engagement in 2021, Region 1 representatives indicated that fish catch had declined over the previous 2 years, although this change was attributed to various factors including changing weather patterns and reduced fishing effort due to the COVID-19 pandemic. Pandemic-related restrictions were particularly noted for their impact on fishing and fish sales, including restriction of fishing hours due to curfews, closure of marketplaces, community lockdowns, changes to export markets, and other public health restrictions.

As indicated in Section 8.1.2.4, Economic Conditions, annual yields in the fishery sector have declined in the last 6 years for fish, and in 4 of the last 6 years for seabob, although seabob yields recovered slightly between 2016 and 2017. Although there are no data available to

quantify the impact of Illegal, Unreported, and Unregulated[17] fishing in Guyana, its role in threatening the sustainability of the country's fishery is considered to be significant (Ministry of Finance 2015; Ministry of Agriculture 2016). Guyana is participating in the regional CLME+ Project[18] to strengthen management of fisheries resources (FAO 2021).

Another challenge faced by fisherfolk is piracy. Most of the fisherfolk interviewed by the Consultants have been victimized by pirates at some time. This typically consists of the theft of boats and/or engines, and fisherfolk are sometimes assaulted in these confrontations. In Region 2, most respondents perceived that piracy had declined in the last 5 or 10 years; some believe the recent establishment of a Coast Guard Station at the mouth of the Pomeroon River has influenced the decrease in piracy. However, most respondents in Region 1 indicated that piracy from Venezuelan vessels has increased over the last 2 to 3 years (Appendix D, Participatory Fishing Survey Final Report January 2019–March 2020). There were reported incidents of piracy from villagers and fisherfolk in Region 1 on the remote and hard-to-access coastal plains in the SBPA, from Tigers Beach to Almond Beach (ERM/EMC 2018). Engagement with Region 1 and Region 2 representatives in 2021 provided mixed reports, with some communities reporting no change in piracy incidents, while the area around the Aruka River and Waini Point reported an increase (EMC 2021). Piracy can present significant risks to the safety of fisherfolk, as exemplified by the 2018 murder of 12 people when four vessels were attacked off the coast of Suriname as a result of a turf-war over fishing grounds (Stabroek News 2020).

Expenses and Income

The economics of the fishing industry can pose challenges to fisherfolk, especially artisanal fisherfolk who tend to operate their businesses on a cash basis and are more susceptible to short-term downturns due to a lack of cash reserves. In interviews conducted as part of the Liza Phase 1 post-permit marine fish survey, some fisherfolk mentioned their operating costs as an economic challenge. Several indicated that fuel represents the most significant expense, which can vary from $1,200 to $3,000 GYD ($6 to $15 USD) per trip for coastal fishing (less than 5 nautical miles [9.3 kilometers] from shore), while for more distant operations (greater than 5 nautical miles [9.3 kilometers] from shore), fuel cost can vary from $10,000 to $50,000 GYD ($50 to $250 USD) per trip. In addition to fuel, fisherfolk mentioned ice, bait, food, net repairs, and miscellaneous expenses as contributing to operating costs (ERM 2018).

Gross income per fishing trip is significantly dependent on the species caught and the prevailing market prices for these species. In March and April 2019, trout was sold for at least $660 GYD ($3.30 USD) per kilogram, shark for $748 GYD ($3.74 USD) per kilogram, and snapper for $880 GYD ($4.40 USD) per kilogram at the Riverview landing site in Region 4. Lower-priced

[17] Illegal, Unreported, and Unregulated fishing takes place where vessels operate in violation of the laws of a fishery. This can apply to fisheries under the jurisdiction of a coastal state or to high-seas fisheries regulated by regional organizations.

[18] The Caribbean Large Marine Ecosystem (CLME+) Project is implemented by the United Nations Development Program and assists countries in ecosystem-based management for living marine resources. In March 2021, national agencies of Guyana and other regional countries participated in a workshop on effective fisheries monitoring, control, and surveillance to combat illegal, unreported, and unregulated fishing.

species included bashaw and cuirass for $132 GYD ($0.66 USD) per kilogram, catfish for $176 GYD ($0.88 USD) per kilogram, bangamary for $220 GYD ($1.10 USD) per kilogram, and butterfish for $375 GYD ($1.88 USD) per kilogram. One vessel had a daily catch of 485 kilograms (1,069 pounds), which was comprised of 217.2 kilograms (443.6 pounds) of trout and 190.5 kilograms (420 pounds) of snapper, and had gross earnings of $63,465 GYD ($317.33 USD). By contrast, another vessel had a haul of 878 kilograms (1,935.7 pounds), almost twice the quantity of the previous vessel, which was comprised of 362 kilograms (798 pounds) of bangamary, 217 kilograms (478.4 pounds) of butterfish, and 290 kilograms (693.3 pounds) of trout/other species, and had gross earnings of $69,946 GYD ($349.73 USD) (Appendix D, Participatory Fishing Survey Final Report January 2019–March 2020). Many fisherfolk indicated that it is necessary to raise the sale price of fish in order to improve their family economies. Additionally, there was a general consensus that catch size has not varied much in recent years, so the economic pressures being felt by fishing families may be related to macroeconomic factors that are external to the fishing industry, rather than the condition of fisheries resources or other industry-related factors (ERM 2018).

Biophysical Changes

The dynamic accretion and erosion of the Guyanese coastline as a result of natural forces can also pose challenges for fisherfolk. During field visits in August/September 2016, late-2017, early-2018, and early-2019, the Consultants observed considerable mudflat and beach accretion at most coastal access points along the coastline, which prevents fisherfolk from landing their boats in some areas (Figure 8.2-5). Saltwater intrusion also occurs up the Moruca River and other smaller rivers in Region 1 in the dry season, and was noted to affect fishing livelihoods in several villages in Region 1 (ERM/EMC 2018). The spread of mangrove vegetation along the shoreline has also impacted the fishing sector. As a result of new mangrove growth and subsequent loss of access to shore, some landing sites had to close and fisherfolk had to relocate to other landings sites (Appendix S, Enhanced Coastal Sensitivity Mapping—Ecosystem Services Final Report).

Figure 8.2-5: Coastal Mudflat at Bushlot Landing Site in Region 5, March 2019

The proliferation of sargassum in fishing grounds has also posed significant challenges to fisherfolk (ERM/EMC Personal Communication 4; Appendix D, Participatory Fishing Survey Final Report January 2019–March 2020; Bank of Guyana 2019). The sargassum fills nets (instead of catch) and lowers yields. During one trip, a fyke net vessel at the Ogle landing site reported approximately 400 kilograms (882 pounds) of sargassum from three pens. The sargassum also results in loss of productive time as fisherfolk have to clean the sargassum from their seines (Figure 8.2-6) and from their catch before sale, as seen on Figure 8.2-7 (Appendix D, Participatory Fishing Survey Final Report January 2019–March 2020).

Figure 8.2-6: Sargassum Tangled in a Fishing Seine

Figure 8.2-7: Fisherfolk Separating Sargassum from Catch at the Zeeburg Landing Site in Region 3

Farming and Agricultural Processing

As discussed above, agriculture is a major livelihood activity in Regions 2 through 6. Rice farming dominates agricultural production in these regions, but other crops, such as red beans, plantains, bananas, eggplants, and other vegetables, are grown on a smaller scale as well. Agriculture is particularly important in Region 6, which had the highest numbers of residents employed in agriculture of any of the coastal regions in late 2017 to early 2018 (ERM/EMC 2018).

In Region 2, most households also raise livestock, such as cattle, hogs, poultry, and small ruminants. The Amerindian community of Mainstay, located approximately 6 kilometers (approximately 3.5 miles) from the coast in Region 2, is known for its organic pineapples, which for a number of years were processed into canned chunks for export to European markets (ERM Personal Communication 4). Coconut cultivation is becoming increasingly popular in the Pomeroon area, as demand for coconut water and other value-added coconut products continues to grow. A number of farms produce coconut water for export to Trinidad and Tobago, while others produce coconut oil. A group established in 2001, the Pomeroon Women's Agro-Processors Association, also produces a number of value-added products, including virgin coconut oil, pepper sauce, cooking sauce, wine, and carambola cake mix (ERM Personal Communication 5).

In the Amerindian communities of Region 1, agricultural activities occur on a small scale and include cultivation of tubers, corn, cucumber, eggplant, ginger, peppers, plantains, bananas, watermelon, beans, okra, pumpkin, and coconut (APA and FPP 2016). At least one community engages in cassava processing, including cassava bread, starch, and cassareep (PAC 2014), but lack of access to markets prevents larger-scale development of this commercial activity.

Challenges for Farmers and Agricultural Processors

Climate change is perceived as a challenge for some agricultural producers. For example, changes in sunshine and rain patterns are thought to have contributed to decreased pineapple yields in recent years (ERM Personal Communication 4). Sea-level rise potentially associated with climate change is also considered a threat for coastal farmers, given that the coastal plains, where the majority of the country's agricultural activity occurs, lie below sea level (ECLAC 2011). Outside of flood events, saltwater sometimes enters into the irrigation canals through sluice gates at high tide or up the Pomeroon River during the dry season. This can adversely impact some crops, such as most vegetables, but may be beneficial to others, such as fruit trees (ERM Personal Communication 5). However, the irrigation canal system for rice fields and fish farms are separated from the drainage system and draw from the water conservancies (see Section 8.1.2.4, Economic Conditions).

Heavy rainfall and resulting flooding can also be detrimental to agricultural producers across the country. In May and June 2021, unprecedented levels of rain fell across all regions. River basins overflowed and flooded inland and coastal areas, and the Ministry of Agriculture reported the destruction of nearly 90 percent of crops as well as livestock losses (Guyana Chronicle 2021). As noted in Section 8.1, Socioeconomic Conditions, flooding had a significant impact at the community level, including loss of crops, farmland, and livestock production in Regions 1 and 2. These impacts have contributed to economic uncertainty and food insecurity for affected households.

Insecure land title has also been identified as a risk to subsistence farming in the indigenous communities of Regions 1 and 2 (APA and FPP 2016), where the majority of villages report having important farming grounds—as well as important hunting, fishing, and gathering grounds—outside of their formal tenure.

Speedboat Operation

Guyana's unique geography means that boating is an important mode of transport for travel between the coastal regions. Other than air travel, the most rapid and direct means of accessing Region 2 from the east coast of the Essequibo River is by speedboat, although a ferry service is also available. Speedboat operators servicing the route between Parika in Region 3 and Supenaam in Region 2 belong to the Supenaam-Parika Speedboat Owners' Association, which currently numbers 91 boats (see Figure 8.2-8). According to a member of the association, the majority of customers for this route are business owners, such as shopkeepers who travel to Georgetown for supplies (ERM Personal Communication 6). Speedboats are also used for transportation to communities upriver on the Essequibo and Pomeroon rivers, and to areas of Regions 1 and 2 that are not accessible by road (i.e., areas west of Charity). In Regions 3 and 4, speedboats are used for transportation across the Demerara River. More information on speedboat use in the coastal areas is provided in Section 8.4, Marine Use and Transportation.

Figure 8.2-8: Speedboats Docked in Parika, Region 3

Challenges for Speedboat Operators

Although natural forces (e.g., wind, waves, sea currents, and sediments transported from the mouth of the Amazon River) create a dynamic and ever-changing coastline, speedboats are typically able to maneuver through mud and sandbanks, where ferries would be unable to traverse (ERM Personal Communication 6). As a result, there are no notable seasonal factors that impact business or safety for speedboat operators. However, some stakeholders noted that along the Pomeroon River, where there are many coconut plantations and processing plants, the practice of discarding coconut shells in the river poses a danger to speedboat operators and passengers (ERM Personal Communication 5 and 6). For speedboat operators plying the Region 1 route, and through the Moruca Sub-Region in particular, the dry season conditions, which can include low water levels in the creeks, can pose a challenge and cause considerable delays.

As for other sectors, the COVID-19 pandemic has presented challenges to speedboat operators as economic activity and inter-regional travel decreased. In Parika, operators reported that decreased economic activity in the region had led to a significant reduction in demand for speedboat services (ERM Personal Communication 28).

8.2.3. Impact Assessment—Employment and Livelihoods

This section assesses potential impacts from the Project's planned activities on employment and livelihoods in the Project's AOI. The following are the potential impacts considered for planned Project activities:

- Potential increased local business activity and employment due to select Project employment, select Project procurement, and Project worker spending;
- Potential for restricted access to remote offshore fishing locations, and potential disruption of fishing vessels and equipment from Project vessel movements; and
- Potential occupational health and safety impacts on Project workers.

8.2.3.1. Relevant Project Activities and Potential Impacts

The primary Project activities will occur approximately 203 kilometers (approximately 126 miles) northeast of the coastline of Georgetown and are not expected to significantly impact non-Project activities occurring on the Guyana coast. The only planned Project activities that will be perceptible from the shore will be support vessel trips originating from and returning to shorebase facilities in Georgetown, and helicopter transits between onshore aviation bases and the FPSO and drill ships offshore.

With respect to increased local business activity and employment, the Project will have direct and indirect potential impacts resulting from employment of Guyanese nationals and use of local companies to supply various goods and services (see Section 2.3, Project Workforce, for details on Project workforce and Section 2.16, Purpose and Need for the Project, for a discussion on Project benefits). The local workforce and local suppliers will also benefit from capacity-building training programs currently undertaken by EEPGL. As described in Section 8.1, Socioeconomic Conditions, EEPGL intends to continue the current approach to optimizing use of local content and continue capacity-building training programs to the extent practicable.

Planned Project activities and the presence of Project vessels are not expected to have significant impacts on fishing livelihoods given the remote location of the activities. Potential impacts on fishing vessels as a result of unplanned events (e.g., collisions between Project vessels and non-Project vessels) are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

Project workers onboard the FPSO and other Project vessels will be exposed to occupational hazards typical of offshore oil and gas operations. As discussed in Chapter 2, Description of the Project, as well as in the Environmental and Socioeconomic Management Plan (ESMP), these will be managed through implementation of EEPGL's Operations Integrity Management System, a robust and effective management system to protect its Project workforce. Therefore, potential occupational health and safety impacts on Project workers are not considered further in this assessment.

Table 8.2-3 summarizes the Project stages and activities that could result in potential Project impacts on employment and livelihoods, as well as the receptors that could potentially experience these impacts.

Table 8.2-3: Summary of Relevant Project Activities and Key Potential Impacts—Employment and Livelihoods

Stage	Receptor(s)	Project Activity	Key Potential Impacts
All Project stages	Population of Georgetown and vicinity	Project procurement of select goods and services	• Increased employment • Increased local business activity and growth
		Worker spending	
		Limited local employment (direct and indirect)	
	Fishing vessel operators in the Project AOI	Transit of Project vessels between the PDA and shorebases in Georgetown and in Guyanese waters between the PDA and shorebase in Trinidad and Tobago	• Disruption of fishing activities due to presence of Project vessels • Minor limitations on fishing access in remote offshore areas due to marine safety exclusion zones [a]
		Establishment of marine safety exclusion zones around major Project vessels in the PDA	

[a] Marine safety exclusion zones will comprise an area of 500 meters (1,640 feet) around the drill ships, and 2 nautical miles (3.7 kilometers) around the FPSO during offloading.

8.2.3.2. Magnitude of Impact—Employment and Livelihoods

The assessment of the Project's magnitude of potential impacts on employment and livelihoods is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on employment and livelihoods is defined according to the definitions provided in Table 8.2-4. The following paragraphs discuss the characteristics of each of the potential impacts assessed, and the resultant magnitude ratings. These are summarized in Table 8.2-5.

Table 8.2-4: Definitions for Intensity Ratings for Potential Impacts on Employment and Livelihoods

Criterion	Definition
Intensity	Negligible: The changes do not bring about any loss of livelihood or employment.
	Low: The changes impact some individual receptors' ability to engage in their current livelihood(s) at the same level of productivity.
	Medium: The changes impact some receptors' ability to engage in their current livelihood(s) at the same level of productivity, and/or cause a loss of working days. The changes impact up to an entire sector within a community in this way.
	High: The changes cause the receptors to cease their current livelihood activities for an extended period of time, or indefinitely. The changes impact up to an entire sector within a region in this way.

Increased Employment

The Project will have limited direct local employment, and most employment opportunities will arise through EEPGL's direct contractors. As of the first half of 2021, the total workforce supporting EEPGL's activities (including direct employees and contractors) amounted to more

than 5,400, more than half of whom (more than 2,800 workers, or 53 percent of total) are Guyanese. The number of Guyanese workers has increased by 35 percent since June 2020 (1,183 Guyanese workers) and is up from 585 in 2018 and 1,183 in 2019.

Modest increases in total employment, including an increase of EEPGL's office staff (for all EEPGL activities), are expected with the development of the Yellowtail Development Project, and EEPGL intends to continue hiring Guyanese nationals to the extent reasonably practicable, in alignment with its Local Content Plan. This impact is considered to be **Positive** and as such, a magnitude rating is not assigned.

Increased Local Business Activity and Economic Growth

In addition to direct employment, the Project will result in the indirect employment of workers through procurement of select local goods and services. Local and foreign workers that are off-shift are also expected to spend a portion of their salaries in the Georgetown area on local accommodations, food, transportation, and entertainment. This increase in business for these local service providers could potentially lead to increased incomes, additional hiring, and continued investment in these local businesses, allowing for further growth.

Beyond ensuring appropriate capacity to perform work or deliver services to EEPGL and its contractors, the capacity-building initiatives delivered to workers and local suppliers will strengthen local workers' and entrepreneurs' skills and employability, providing employment and livelihood benefits over the longer term. The Bureau of Statistics anticipates that Guyanese will become wealthier as a result of the oil and gas sector, and this may result in improved quality of living. For example, as people become wealthier, they are likely to be interested in owning their own home, resulting in an increase in the number of households (ERM/EMC Personal Communication 9). This impact is considered to be **Positive** and as such, a magnitude rating is not assigned.

Limitations on Industrial Fishing in Remote Offshore Areas

Few potential adverse impacts on employment or livelihoods are expected as a result of planned Project activities. Current fishing activities (both industrial and artisanal) rarely occur as far offshore as the PDA, and according to various members of the industrial and artisanal fishing community as well as the Fisheries Department, the marine safety exclusion zones are expected to have little or no impact on existing fishing activity (ERM Personal Communication 22).

As of 2019, one commercial fishing company, Pritipaul Singh Investments, with 12 vessels capable of participating in deepwater tuna fishing (ERM/EMC Personal Communication 4; ERM Personal Communication 24) may approach the southern boundary of the PDA, and abandoned fishing gear was found in 2018 entangled in the mooring lines for metocean instruments installed by EEPGL in the same general vicinity. There are also reportedly Venezuelan vessels that fish on occasion at depths as far out as 190 kilometers (118 miles) near the PDA, but no further information was obtained by the Consultants to confirm these reports (ERM Personal Communication 23). If deepwater fishing continues to develop in the vicinity of the PDA, the

number of industrial fishing vessels affected by Project-related activities offshore may increase modestly in the future, but would still be a relatively small amount of vessels compared to the overall fishing fleet in Guyana.

Considering the small number of operators that are currently participating in deep-sea fishing (no more than 12 vessels) and the ability to provide information in advance about EEPGL operations and marine safety exclusion zones, the intensity of the related impact on the **Direct AOI** is rated as **Low**. Situations resulting in the inability of deep-sea fishing vessels to use the relatively small area of ocean that will be affected, will be **Episodic**, but the potential for such situations will extend across the life of the Project (at least 20 years), and are therefore considered to be **Long-term**. Consequently, the magnitude of the Project-related potential impacts on industrial fishing operations is considered **Small**.

Disruption of Artisanal Fishing Activities in Nearshore Areas

The highest potential for Project interactions with fisherfolk may be encounters with support vessels transiting between the PDA and shorebases in Georgetown. This could result in some limited and temporary disruption to fishing activity. Unlike deepwater industrial fisheries, the artisanal fisheries will not lose access to any fishing areas as a result of marine safety exclusion zones within the PDA (as these are in areas where artisanal fishing does not occur). However, increased Project-related vessel traffic near the coast and within the Demerara Harbour carries a small increase in the potential for support vessels to disrupt fishing vessel activities, and the intensity of the related impact in the **Direct AOI** is thus rated as **Low**. Situations resulting in the inability of artisanal fishing vessels to continue normal operations as a result of increased vessel activity will be **Episodic**, but the potential for such situations will extend across the life of the Project (at least 20 years), and are therefore considered to be **Long-term**. Consequently, the magnitude of the Project-related potential impacts on artisanal fishing operations is considered **Small**.

Table 8.2-5: Magnitude of Impact—Employment and Livelihood

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
All Project Stages	General population of Georgetown and vicinity—Increased employment	Direct AOI (Georgetown and vicinity)	NA	NA	NA	NA
	General population of Georgetown and vicinity—Increased local business activity and growth	Direct AOI (Georgetown and vicinity)	NA	NA	NA	NA
	Fishing vessel operators (primarily artisanal) in the Direct AOI—Disruption of fishing activities nearshore due to presence of Project vessels	Direct AOI (Nearshore and Demerara Harbor)	Low	Episodic	Long-term	Small
	Fishing vessel operators (industrial) in the Direct AOI—Minor limitations on fishing access in remote offshore areas due to marine safety exclusion zones	Direct AOI (Offshore in PDA)	Low	Episodic	Long-term	Small

NA = not applicable (Positive impact, so no magnitude rating assigned)

8.2.3.3. Sensitivity of Receptors—Employment and Livelihoods

Potential receptors for employment and livelihood impacts are the general population in Georgetown and its vicinity (for positive impacts related to increased business and employment) in the Direct AOI; and subsistence and commercial fisherfolk operating on the Guyanese coast in the Indirect AOI (for impacts related to fishing activity). The receptor sensitivity ratings for employment and livelihoods are defined in Table 8.2-6.

Table 8.2-6: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Employment and Livelihoods

Criterion	Definition
Sensitivity	Low: The receptor can easily adapt to the change without assistance or can shift to alternate livelihood opportunities without impacting ability to subsist and/or earn income.
	Medium: The receptor may adapt to the change or shift to alternate livelihood activities with assistance and with some disruption to ability to subsist and/or earn income.
	High: The receptor cannot adapt to the change without difficulty and cannot easily transition to alternate livelihood activities. Impacts on current livelihood activities will pose a threat to the receptor's ability to subsist, earn income, and maintain current quality of life.

Receptors in the Georgetown area (Region 4) are considered to have a **Medium** level of sensitivity to the Project's potential positive employment and livelihood impacts, since the workforce in this region has a comparatively higher likelihood to take advantage of increased employment activities, relative to the greater Guyanese population.

Artisanal fisherfolk engaging in fishing on the Guyanese coast have a limited ability to adapt to potential fishing disruption impacts from Project activities, and are thus considered to have a **Medium** level of sensitivity to such impacts.

Industrial fisherfolk are generally better able to adapt to increased vessel activity and limited decreases in accessibility to offshore areas for fishing. However, as a conservative measure and in recognition of the variability in ability to adapt across the sector, industrial fisherfolk are considered to also have a **Medium** level of sensitivity to potential impacts on fishing activity.

8.2.3.4. Impact Significance—Employment and Livelihoods

As discussed above, the potential impacts on employment and livelihoods that will result from Project employment, procurement, and worker spending are considered to be **Positive**. As described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, this assessment does not develop significance ratings for positive impacts.

Based on the magnitude of impact and the receptor sensitivity ratings, the significance of potential adverse livelihood and employment impacts on industrial and artisanal fisherfolk operating in the coastal area and industrial fisherfolk operating offshore near the PDA is rated as **Minor**.

8.2.4. Management Measures—Employment and Livelihoods

The Project will seek to enhance positive benefits to employment and livelihoods by procuring select goods and services locally (potentially leading to enhanced local employment and livelihood benefits) to the extent reasonably practicable. Table 8.2-7 summarizes the embedded controls, mitigation measures, and monitoring measures relevant to this receptor.

Table 8.2-7: List of Embedded Controls, Mitigation Measures, and Monitoring Measures

Embedded Controls
Employ Guyanese citizens having the appropriate qualifications and experience where reasonably practicable. Partner with select local institutions and agencies to support workforce development programs and proactively message Project-related employment opportunities.
Procure Project goods and services from Guyanese suppliers when available on a timely basis and when they meet minimum standards and are commercially competitive.
Mitigation Measures
Notices to Mariners are issued through the Maritime Administration Department for their communication with the public, and information is provided to the Department of Fisheries for their distribution to stakeholders (including associations, co-ops, and fisherfolk) within the fishing industry in country, regarding movements of major marine vessels (including the FPSO, drill ship, and installation vessels) to aid them in avoiding areas with concentrations of Project vessels and/or where marine safety exclusion zones are active.
Augment ongoing stakeholder engagement process (along with relevant authorities) to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners and, where possible, communicate with them regarding major vessel movements and marine safety exclusion zones.

Monitoring Measures
Monitor percentage of Project Workforce made up of Guyanese nationals on a quarterly basis
Monitor percentage of Project goods and services expenditures procured locally on a quarterly basis
Monitor frequency of engagement with stakeholders, including fisherfolk, coastal communities, vulnerable groups, and indigenous populations

As a mitigation measure to address the potential for adverse impacts on fishing activities, the Project intends to issue notices to mariners via the Maritime Administration Department (MARAD), as well as via the Trawler's Association and fishing co-ops for major marine vessel movements, including movements of the FPSO, drill ships, and major installation vessels. Notices will aid other marine users so they can avoid areas where concentrations of Project vessels and/or safety exclusion zones may be present. The Project will also continue to communicate major vessel movements to commercial cargo, commercial fishing, and subsistence fishing vessel operators, including those vessels known to operate in the vicinity of the PDA, who might not ordinarily receive Notices to Mariners, and where possible, communicate Project activities to those individuals to aid them in avoiding Project vessels through the stakeholder engagement process. This will allow fishing boat operators to adjust their fishing locations if needed to avoid these offshore locations with higher densities of Project vessels. With implementation of this mitigation measure, the significance of potential impacts on industrial fisherfolk is considered to be reduced to **Negligible**.

Many of the artisanal craft engaged in subsistence fishing activities do not carry radios, may use remote ports, and/or may not receive notices of increased vessel activity issued by the Project through the channels described above. Accordingly, this mitigation measure is likely to be somewhat less effective for artisanal fisherfolk. For this reason, while the same mitigation measure described above will be applied to address potential impacts on artisanal fisherfolk, including regular engagement on Project-related activities, the significance of potential impacts is maintained at a rating of **Minor**.

Table 8.2-8 summarizes the assessment of potential pre-mitigation and residual Project impacts on employment and livelihoods. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the employment and livelihoods-specific methodology described in Sections 8.2.3.2, Magnitude of Impact—Employment and Livelihoods, and 8.2.3.3, Sensitivity of Receptors—Employment and Livelihoods.

Table 8.2-8: Summary of Potential Pre-Mitigation and Residual Impacts—Employment and Livelihoods

Stage	Resource/ Receptor Impact	Magnitude Rating	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	Population of Georgetown and vicinity—increased employment, local business activity, and household incomes	Positive	Medium	Positive	None	Positive
	Industrial Fisherfolk—impacts on fishing livelihoods (marine safety exclusion zones within the PDA for commercial fishing operations; nearshore navigation and safety for subsistence fishing operations)	Small	Medium	Minor	• Notices to Mariners and other communication materials regarding major vessel movements and marine safety exclusion zones • Augment ongoing stakeholder engagement process to communicate Project activities to the fishing community, including individuals who might not ordinarily receive Notices to Mariners	Negligible
	Artisanal Fisherfolk—impacts on fishing livelihoods (marine safety exclusion zones within the PDA for commercial fishing operations; nearshore navigation and safety for subsistence fishing operations)	Small	Medium	Minor		Minor

8.3. COMMUNITY HEALTH AND WELLBEING

8.3.1. Administrative Framework—Community Health and Wellbeing

Table 8.3-1 summarizes the legislation, policies, or treaty commitments that are specifically relevant to the assessment of potential impacts on community health and wellbeing.

Table 8.3-1: Legislation, Policies, or Treaty Commitments—Community Health and Wellbeing

Title	Objective	Relevance to the Project
Legislation		
Food & Drug Regulations (Food and Drug Act, 1971)	Regulates the sale, advertisement, preparation, and handling of food products; regulates the manufacture, advertisement, trade, and administration of pharmaceuticals; provides the Ministry of Health authority to inspect facilities to establish compliance with sanitation standards.	Governs the preparation of food and provision of medications at Project facilities.
Occupational Safety and Health Act, 1997	Legally defines the responsibilities of workers and management with respect to keeping workplaces safe.	Generally applies to Project workers and Project-related activities.
Health Facilities Licensing Act (2007) and Health Facilities Licensing Regulations (2008)	Under the act, all health facilities must be licensed by the Minister of Health. The act also provides for inspectors who are authorized to enter any facility and conduct inspections. Offenses are outlined with fines and imprisonment upon summary conviction. Importantly, the act also provides for the Minister to make regulations related to licenses, renewals, and standards for health facilities; record keeping; and prescribing and governing the construction, establishment, location, equipment, maintenance, repair of, additions and alterations to, and operations of health facilities. Licensing regulations address licensing and operation of health facilities including governance, health and safety, hygiene, staffing, policies and procedures, and oversight / quality assurance requirements.	Sets the requirements for health facilities at which services would be available to Project workers.
Policies		
Health Vision 2020: National Health Strategy for Guyana (2013)	Creates an enabling framework for the integrated delivery of quality, effective, and responsive health services and prevention measures to improve the physical, mental, and social wellbeing of all people in Guyana.	Seeks to improve service delivery; managing communicable and non-communicable diseases; and improving health outcomes.

8.3.2. Existing Conditions—Community Health and Wellbeing

This section describes the existing community health and wellbeing characteristics of the Project AOI. This profile is based on secondary information contained in Project-related materials, socioeconomic reports and data provided by government entities and other stakeholders, and other relevant data received from public sources. Due to the availability of health data, this section focuses on national and regional profiles; community-specific data is not publicly available. Recent data sources, including data on COVID-19, have also been incorporated, where available; however, not all statistics and/or reports are regularly updated and recent sources are not available for all indicators.

This section also incorporates information obtained directly from stakeholder engagement and key informant interviews (conducted between 2017 and 2021) with members of national, regional, and local governments; civil societies and NGOs; local community members; and other Project stakeholders. Specific stakeholder engagement information can be found in Section 4.7, Stakeholder Engagement.

8.3.2.1. Health Status

According to the Ministry of Health, health outcomes in Guyana have steadily improved over recent decades (Persaud 2013). From 2000 to 2016, there was a 0.9 percent increase in personal healthcare access and quality. Life expectancy for all births increased from 64 years (during the period 1990 to 2002) to 73.4 years for females and 67.8 years for males in 2017 (IHME 2017). The crude death rate[19] decreased from 6.6 per 1,000 persons in 2003 to 6.1 per 1,000 persons in 2011 (Persaud 2013). The leading causes of mortality in 2017 were chronic diseases (including cardiovascular and cerebrovascular diseases), cancers, diabetes, and hypertension (IHME 2017). Road injuries, interpersonal violence, and self-harm were the most prevalent causes of injury in 2017 (IHME 2017).

Burden of Disease

As with many other developing countries, Guyana is undergoing an epidemiological transition by which non-communicable diseases are beginning to replace communicable diseases as the leading causes of illness and mortality, although communicable diseases are still prominent in the disease profile. This shift is largely due to trends toward more sedentary occupations and lifestyles, as well as unhealthy diets and habits such as tobacco and alcohol use. Non-communicable diseases are the most significant public health challenge facing Guyana (Ministry of Finance 2018; WHO 2018). In 2019, the cause of death by non-communicable disease increased to 69.7 percent, marking an increase of more than 2.3 percent since 2015 (World Bank 2021).

[19] The crude death rate is the number of deaths occurring among the population of a given geographical area during a given year, per 1,000 mid-year total population of the given geographical area during the same year (OECD 2013b).

Non-communicable Disease

The most common non-communicable diseases and causes of illness/mortality in 2013 were diabetes, cardiovascular diseases, heart diseases, hypertension, cancers, chronic lung diseases, gastroenteritis and liver disease, accidents, violence-related injuries, and mental illnesses (Persaud 2013). The disease profile was similar in 2017, with the most common mortality-causing non-communicable diseases being heart diseases (ischemic and hypertensive), stroke, diabetes, chronic kidney diseases, and cirrhosis. Specifically, in 2017 compared to 2007, there were 32 percent more deaths from hypertensive heart disease, 31.5 percent more deaths from chronic kidney disease, 17.8 percent more deaths from stroke, 16.6 percent more deaths from ischemic heart disease, and 10.3 percent more deaths from diabetes (Ministry of Finance 2018; WHO 2018).

Obesity is on the rise in the country, along with other forms of malnutrition. Although Guyana is considered self-sufficient for food, the population's access to, and utilization of, the right types of food to maintain health are of concern. This has led the Ministry of Agriculture to develop the Guyana Food and Nutrition Security Strategy 2011–-2020 Plan (Ministry of Agriculture 2011). This plan aims, among other goals, to integrate agricultural practices with improved food security and nutrition (Ministry of Health 2013a). According to the Ministry of Health, in 2013, 6.2 percent of the population had been diagnosed with diabetes, with an estimated incidence rate of 4,000 new cases annually. Type 2 (non-insulin dependent) diabetes accounted for 92 percent, with Type 1 (insulin-dependent) making up the other 8 percent (Persaud 2013). In 2018, incidence of diabetes continued to increase (Ministry of Finance 2018).

Hypertension is also on the rise, with a 2013 prevalence rate of 9 percent of the population over 30 years old and with an estimated 16,000 new cases reporting annually. Hypertension is the major contributing cause of strokes for persons over 40, as well as for heart attacks, disability, and other health issues affecting productivity of working age adults (Persaud 2013). In 2018, incidence of hypertension continued to increase (Ministry of Finance 2018).

Communicable Disease

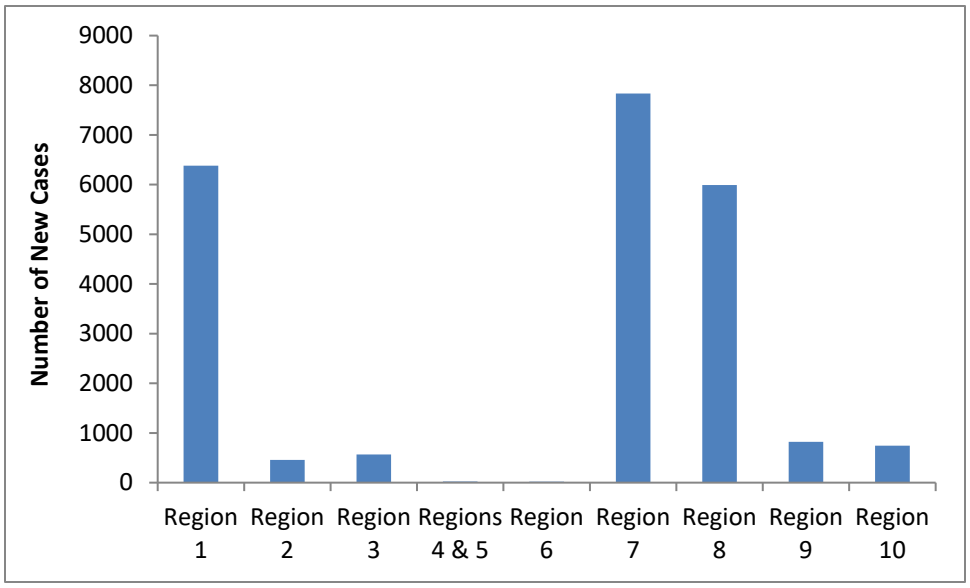
Communicable diseases also continue to impact productivity, quality of life, and wellbeing in Guyana, particularly in the hinterland regions. This is due to a number of interrelated factors including poverty, nutritional deficiency, and inadequate access to health services. In 2012, the most common communicable diseases were malaria (31,876 cases), tuberculosis (TB) (725 cases), and human immunodeficiency virus (HIV) (8,263 cases out of 106,492 tested) (Persaud 2013).

Malaria is found in much of Guyana and is most prevalent in Regions 1, 7, and 8. Malaria control efforts, such as distribution of insecticide-treated bed nets and indoor residual spraying[20], have been ongoing in these regions for decades. After an initial reduction in malaria prevalence in the early 2000s, the number of cases increased from 2007 to 2012. Data indicate

[20] Indoor residual spraying involves coating the walls and other surfaces of a house with an insecticide that has residual activity (i.e., continues to work over several months, killing mosquitos on contact with the sprayed surfaces) (Centers for Disease Control and Prevention 2019).

a correlation with mining activities in the hinterland areas, and the country's Central Vector Control Service now sends mobile teams to work directly with populations residing in mining camps (USAID 2014). There was a decrease in 2013, with figures released by the Ministry of Health showing that in 2013, there were 23,489 reported cases of malaria, compared to 31,876 for the previous year (Persaud 2013). In 2019, malaria cases increased to 18,830 cases, an increase of 11 percent from 2018 (Rios 2021). Recent floods in Guyana have posed a risk of increased incidences of malaria in hinterland regions. Region 9 reported more than 284 cases in the wake of the May 2021 floods in the region (Guyana Times 2021).

Figure 8.3-1 shows the number of reported new malaria cases for each region in 2019, the most recent year for which data broken down by region are available. As in prior years, Regions 1, 7, and 8 exhibit the highest number of malaria cases.



Source: Malaria Atlas Project 2021

Figure 8.3-1: Malaria Incidence by Region, 2019

Dengue fever, chikungunya, lymphatic filariasis, and Zika are also locally transmitted in Guyana (i.e., they are present in the community and passed from Guyanese to Guyanese). Unlike malaria, transmission of these diseases tends to be common in populated and urbanized areas.

Lymphatic filariasis and soil-transmitted helminthiasis continue to be problematic in Guyana, leading to deformity, malnutrition, and social stigma in impacted populations. In 2017, lymphatic filariasis was the tenth most common cause of disability from illness in Guyana (IHME 2017). Efforts to combat these diseases include mass drug administration campaigns and improvements in sanitation in endemic areas.

TB continues to be a priority health concern in Guyana. It was nearly eradicated in the 1980s, but saw a resurgence in the 1990s due to its association with the HIV/acquired immunodeficiency syndrome (AIDS) epidemic. In 2019, the country had a TB incidence rate of 79 per 100,000, following a decade of fluctuation from 2010 to 2019 (WHO 2019; Knoema

2020). For comparison, the global incidence in 2019 was 130 per 100,000. The estimated burden of TB in Guyana in 2019 is shown in Table 8.3-2.

In 2019, the number of people living with HIV in Guyana was estimated at 8,700, and the prevalence rate in the population aged 15 to 49 was 1.4 percent (UNAIDS 2021; Table 8.3-3). Progress has been made in addressing the HIV epidemic in the country, with a significant reduction in HIV incidence (per 1,000 population) since 2003; however, between 2008 and 2017, AIDS mortality (per 1,000 population) slowly increased from 0.11 to 0.15, before levelling at 0.14 in 2018 and 2019 (UNAIDS 2021).

Table 8.3-2: Estimates of TB Burden in Guyana, 2019

Estimates of TB Burden [a]	Number	Rate (per 100,000 population)
Total incidence (includes HIV+TB)	620 (480–790)	79 (61–100)
HIV-positive incidence	120 (84–160)	15 (11–20)
HIV-negative TB mortality	120 (110–130)	15 (14–16)
HIV-positive TB mortality	25 (17–35)	3.2 (2.2–4.4)

Source: WHO 2019

[a] Ranges represent uncertainty intervals.

Table 8.3-3: Estimates of HIV and AIDS Prevalence in Guyana, 2019

Population Living with HIV [a]	Number	Rate (per 100,000 population)
Total adults and children	8,700 (7,800-9,700)	n/a
Adults (aged 15 and over)	8,300 (7,400-9,300)	1.4 (1.2-1.5)
Women (aged 15 and over)	4,100 (3,700-4,500)	1.3 (1.2-1.5)
Men (aged 15 and over)	4,300 (3,700-4,800)	1.4 (1.2-1.6)
Children (aged 0 to 14)	<500 (<500-<500)	NA

Source: UNAIDS 2021

[a] Ranges represent uncertainty intervals.

Maternal and Child Health

Guyana has made improvements in maternal and child health in recent years, but did not achieve the Millennium Development Goal targets of reducing child mortality rates by two-thirds, and maternal mortality ratio by three-quarters between 1990 and 2015 (UNDP Undated_a). Over the period 2015 to 2030, Guyana is working towards achieving the targets for the Sustainable Development Goal for maternal and child health (UNDP Undated_b). This includes reducing maternal mortality to less than 70 per 100,000 live births. In 2018, Guyana's maternal mortality ratio was estimated at 116.7 per 100,000, a significant improvement from 229 per 100,000 in 2015 (Green State Development Strategy 2019). Sustainable Development Goal targets also include ending preventable deaths of newborns and children under 5 years of age, reducing neonatal mortality to at least as low as 12 per 1,000 live births, and reducing under-5 mortality to at least as low as 25 per 1,000 live births. Guyana's neonatal mortality rate was 20.8 per 1,000 live births and under age 5 mortality was 20.8 per 1,000 live births in 2018 (Green State Development Strategy 2019).

The crude birth rate[21] declined from 22.8 per 1,000 persons in 2003 to 17.7 per 1,000 persons in 2011, and the infant mortality rate has declined from 17 to 15.1 per 1,000 live births during this same time period (Persaud 2013). However, marked disparities exist in rural and hinterland areas. In 2014, the rate of under-5 mortality in rural areas (48 per 1,000 live births) was more than four times the rate in urban areas (11 per 1,000 live births) (BSG et al. 2015).

The primary causes of infant death at birth include premature birth and respiratory distress, both of which are preventable, with the secondary causes being congenital deformity and birth defects that are not preventable (Persaud 2013). According to interviews with health workers in late 2017 and early 2018, home deliveries are common in many remote areas due to the lack of ambulance services and general access to transportation to neighboring healthcare facilities. In some remote healthcare facilities, the lack of basic medical supplies means that health workers must rely on rudimentary equipment to perform births (e.g., scalpel to cut umbilical cords, no electricity) (ERM/EMC 2018).

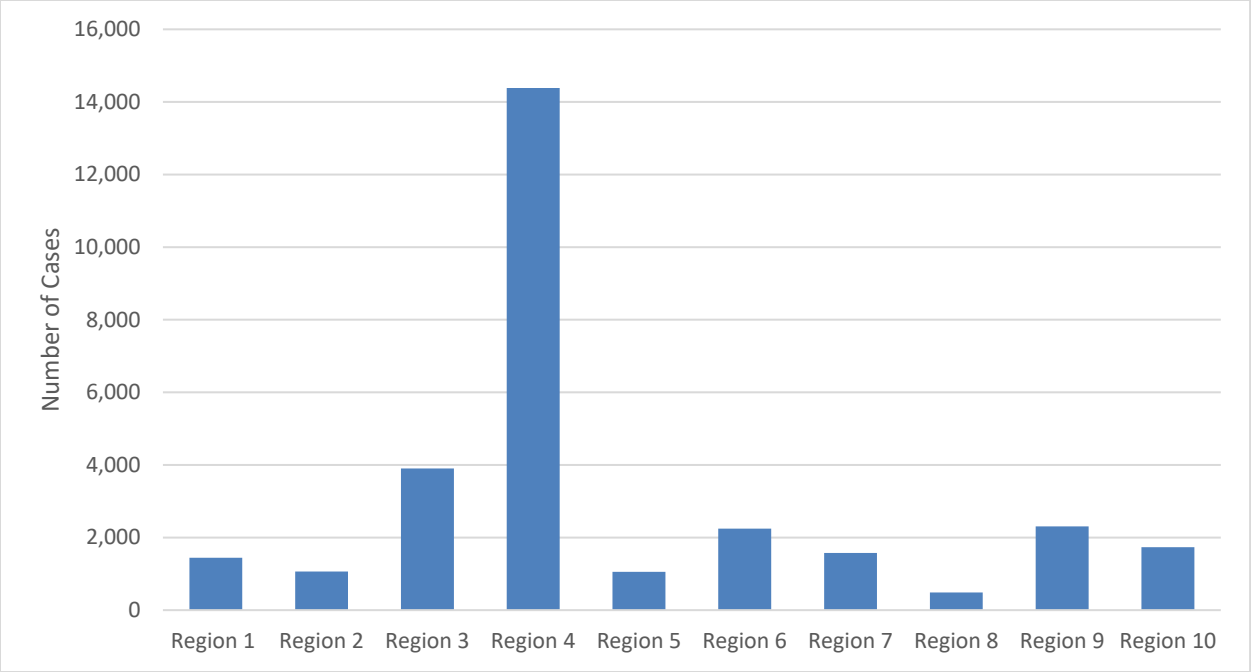
Mental Health

Guyana reports a relatively high suicide rate at the national level. Since 2008, the crude suicide rate has shown a generally increasing trend from 29.98 deaths per 100,000 people in 2008, to a high of 40.28 in 2019 (the most recently available annual data; WHO 2021). In 2019, Guyana marked the second-highest country-level suicide rate (WHO 2021), and suicide was the third major cause of death in the 15 to 44 age group (Green State Development Strategy 2019). According to Guyana's Chief Medical Officer, rates are particularly high in Regions 2, 3, and 6, with the most common method being ingestion of poisons such as pesticides. No single reason is pinpointed for this phenomenon, but the shortage of mental health workers and the stigma associated with mental illness—leading to untreated depression—are thought to be contributing factors, as well as the ease of access to pesticides and other toxic agricultural substances (ERM Personal Communication 7).

COVID-19

Guyana has been responding to the global COVID-19 pandemic since March 2020 when the virus appeared in the Guyanese population. Infection rates and deaths have since increased. As of 22 September 2021, the country had recorded 740 deaths from COVID-19 and a total of 30,186 cases (Ministry of Health 2021). The regional breakdown of cases is illustrated in Figure 8.3-2.

[21] The crude birth rate is the number of live births occurring among the population of a given geographical area during a given year, per 1,000 mid-year total population of the given geographical area during the same year (OECD 2013a).



Source: Ministry of Health 2021

Figure 8.3-2: Guyana COVID-19 Cases by Region (22 September 2021)

The pandemic has impacted all regions of the country, including the most populous Region 4, but it has posed a particularly serious threat to the regions mostly inhabited by Indigenous Peoples, requiring extensive lockdowns in villages and communities. Regions 1, 7, and 9 were particularly hard-hit by the pandemic, requiring the establishment and upgrade of regional health facilities to provide care for infected persons. The Infectious Diseases Hospital and other COVID-related facilities are described in Section 8.3.2.2, Healthcare System.

The impact of the pandemic on the health care system of Guyana has been significant and necessitated additional funding to the health sector for focused interventions. The challenges of the pandemic are stretching the country's public health system (World Bank 2020). Interventions have included the establishment of a specialized hospital for serious COVID-19 cases and upgrades to regional and secondary hospitals. In 2020, approximately 15 percent of the national emergency budget ($51.7 billion GYD or $258.5 million USD) was allocated to the health sector (Stabroek News 2020). In 2021, $53.5 billion GYD ($267.5 million USD) was identified for ongoing response to COVID-19 and its effects. The budget also provided $750 million GYD ($ 3.75 million USD) for the procurement of COVID vaccines, medical supplies, test kits, sanitizing materials, personal protective equipment, and the roll out of an immunization program.

The Government of Guyana also sought and received funding from the World Bank for a project to address COVID-19 impacts on the health sector. The Guyana COVID-19 Emergency Response Project is funded by an International Development Assistance credit of $1.586 billion GYD ($7.93 million USD). The project objectives include the prevention, detection, and

response to the threat posed by COVID-19 and the strengthening of national systems for public health preparedness (World Bank 2020).

8.3.2.2. Healthcare System

The Ministry of Health is responsible for setting national policy, regulation, and standards; building and refurbishing healthcare facilities; and financing the employment of doctors, nurses, and emergency response workers. At the regional level, the Regional Health Authorities have the autonomy to assess, plan, and implement health services and manage the facilities for a defined population in a defined geographic area, including day-to-day management of the facilities and employment of all other staff working in the health sector. The country's main framework for health is the Health Vision 2020, which sets the strategy and overall planning for the health sector (Ministry of Health 2013b).

Government health spending is low compared to other Latin American and Caribbean countries, averaging $46,000 GYD ($230 USD) per capita compared to an average of $137,000 GYD ($685 USD) for the region (World Bank 2020). Out-of-pocket health expenditures represent 32.4 percent of overall expenditure, and concerns about access to health care for vulnerable populations have been highlighted (World Bank 2020). In the 2021 budget, $53.5 billion GYD ($267.5 million USD) was allocated to healthcare (DPI Guyana 2021). The healthcare system in the country is highly decentralized, with RDCs and Regional Health Authorities managing, financing, and providing health services. However, the system continues to have a number of challenges related to human resources capacity and infrastructure capacity, which is especially acute in remote areas, such as Region 1.

The Ministry of Health established priorities in 2013 for the national healthcare system to increase financial and technical support to improve the following (Persaud 2013):

- Family health (child, adolescence, women, men, elderly);
- Disease eradication and mental health;
- Violence, accidents, and injury rates;
- Healthcare facilities at all levels (community centers to city hospitals);
- Nutrition and food security; and
- Access to health for frontier, migrant, remote, and vulnerable populations.

Healthcare Facilities

Healthcare facilities in the coastal regions are summarized in Table 8.3-4. In addition to these facilities, there is one National Ophthalmology Center and one National Psychiatric Hospital in the country, both located in Region 6.

Table 8.3-4: Health Care Facilities in the Coastal Regions

Region	Regional Hospital	District Hospital	Diagnostic Center	Health Center	Health Post
Region 1	1	4	—	4	44
Region 2	—	2	1	11	17
Region 3	1	2	1	17	22
Region 4	1	1	1	39	7
Region 5	—	1	1	14	1
Region 6	1	3	—	21	2

Source: Ministry of Health 2020

According to Guyana's Chief Medical Officer, one of the biggest health system shortfalls for Guyana is unreliable emergency care services. This includes the lack of a functioning air ambulance system, which is needed to adequately respond to mining injuries in the country's interior and to the large number of vehicle accident-related injuries. There are also shortages of blood at times, and capacity in hospitals is inadequate. The public hospital in Georgetown once had 900 beds, but due to fires and dilapidation over the years, this has been reduced to 450 (ERM Personal Communication 7). In 2012, there were 28 hospital beds per 10,000 people in the country, up slightly from 25 beds per 10,000 people in 2003 (Persaud 2013; ERM/EMC 2018). The most common reasons for clinic visits were hypertension, diabetes, antenatal, and family planning. Medical supplies, including medicines, are in short supply and those that are provided to village health centers from larger cities (such as Mabaruma and Georgetown) are typically close to, if not past, the expiration date.

The Infectious Diseases Hospital, commonly called the COVID Hospital, was commissioned at Liliendaal, Georgetown, in July 2020 to serve as the premier institution for the quarantining and isolation of persons who have been infected with COVID-19 and other infectious diseases (Newsroom Guyana 2021). The hospital has a capacity of 200 beds and an Intensive Care Unit (ICU) capacity of 40 beds. As of 22 September 2021, there were approximately 4,070 active COVID-19 cases in the country with 151 persons hospitalized; 97 of these positive cases were housed at the Infectious Diseases Hospital with 36 of these in its ICU (Ministry of Health 2021). The Ministry of Health is currently working to expand the capacity of the hospital by adding 10 ICU beds and 50 regular ward beds, and the second floor of the hospital has been re-fitted with piped oxygen to prepare for additional patients. The government is in the process of expanding COVID-19 capacity at the regional hospitals, and plans to close services at selected hospitals across the country to provide additional COVID treatment facilities, should the need arise, as well as to utilize a field hospital (a donation from Qatar) to boost the country's COVID-19 response capacity (Village Voice News 2021).

Health Human Resources

Retention of healthcare professionals in Guyana is a challenge, as in many other developing countries that see emigration of skilled workers to developed countries. The most recent available statistics from the World Bank indicate that there were eight physicians and 10.4 nurses per 10,000 people in the country in 2020 (World Bank 2020). Guyana's Health Human Resource Action Plan for Guyana 2011-2016 aimed to address this issue.

8.3.2.3. Quality of Life

Water and Sanitation

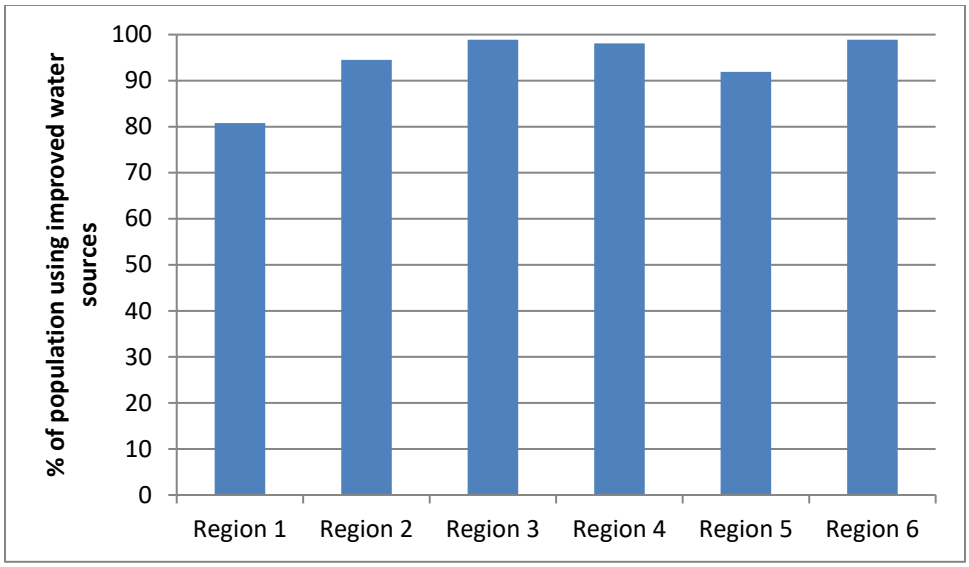
According to the most recent Guyana Multiple Indicator Cluster Survey (MICS)[22], 94 percent of Guyana's population had sustainable access to improved drinking water sources[23] as of 2014, and 95.4 percent used an improved sanitation facility[24] (UNICEF 2014). According to the Green State Development Strategy, 96 percent of the population is noted as having access to potable water (Green State Development Strategy 2019). Figure 8.3-3 shows the percentage of the population with access to improved sources of drinking water, by region. However, while access to improved water sources has improved over the years, wastewater and sanitation coverage and infrastructure in the country are limited, thus hampering efforts to improve health conditions (World Bank 2016).

In 2012, approximately 97 percent of the population in both urban and rural areas used an improved drinking-water source (as compared to 83 percent in rural areas in 2000). However, an assessment conducted by multilateral partners in 2014 points out that the quality of water supply services is hindered by decaying distribution networks, with 50 percent to 70 percent of wastewater going unaccounted for at the national level (and more than 70 percent in Georgetown) (World Bank 2016).

[22] The MICS program was developed by the United Nations Children's Fund and serves as an international household survey program to collect internationally comparable data on a wide range of indicators on the situation of children and women.

[23] Improved water sources refer to any of the following types of supply: piped water into dwelling, compound, yard, to neighbor, or to public tap/standpipe; tube well/borehole; protected well; protected spring; and rainwater collection. Bottled water is considered an improved water source only if the household is using an improved water source for handwashing and cooking.

[24] An improved sanitation facility is defined as a facility that flushes or pour-flushes to a piped sewer system, a septic tank, a pit latrine, a ventilated improved pit latrine, or a pit latrine with slab.



Source: UNICEF 2014

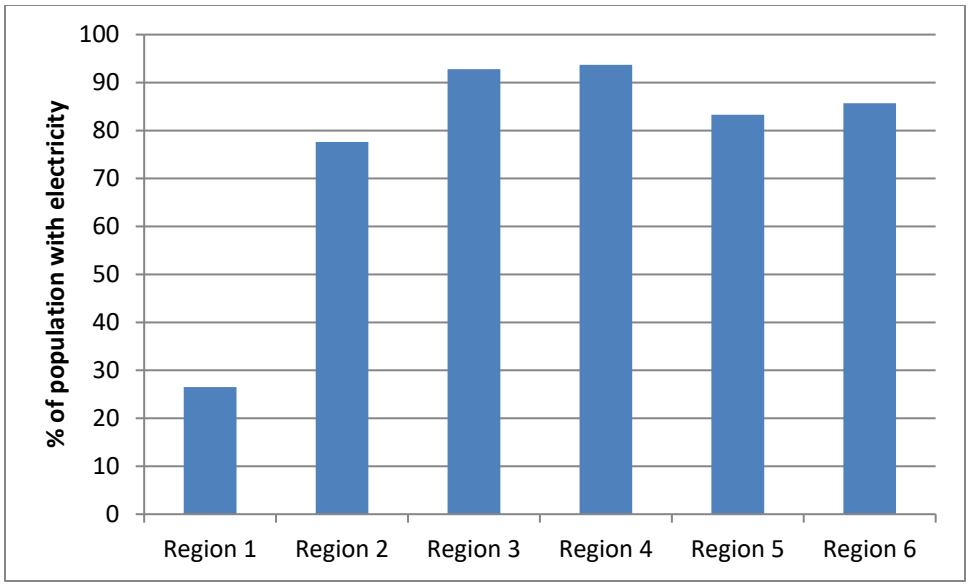
Figure 8.3-3: Percent of Population with Access to Improved Water Sources by Region, 2014

According to representatives from the Ministry of Communities[25], projects are being implemented in hinterland regions to significantly increase access to potable water and improve sanitation (ERM/EMC Personal Communication 6). Under the *Hinterland Sustainable Housing Programme*, the Ministry of Communities intends to provide better access to housing, potable water, and sanitation to four communities in Region 1 and nine communities in Region 9 (Ministry of Local Government and Regional Development 2016). In addition, Guyana Water Inc. (GWI) has established wells in Koboremo, Kamwatta, and Toko, and rehabilitated water catchment areas in Matthew's Ridge and Mabaruma in Region 1. New wells were also established at Silver Hill, Waikabra, and Hill Foot in Region 4. GWI is working toward increasing access to treated water in Mabaruma and Matthew's Ridge in Region 1. In addition, new water treatment plants are planned for several locations in Region 4, including Diamond, Timehri North, Bladen Hall, Sparendaam, and Sophia (Guyana Chronicle 2018).

Electricity

Results of the MICS indicate that an estimated 91.2 percent of the coastal population and 56.2 percent of the interior population have access to electricity. Figure 8.3-4 shows the percent of the population with electricity in each of the coastal regions.

[25] The Ministry has been renamed to Ministry of Local Government and Regional Development.

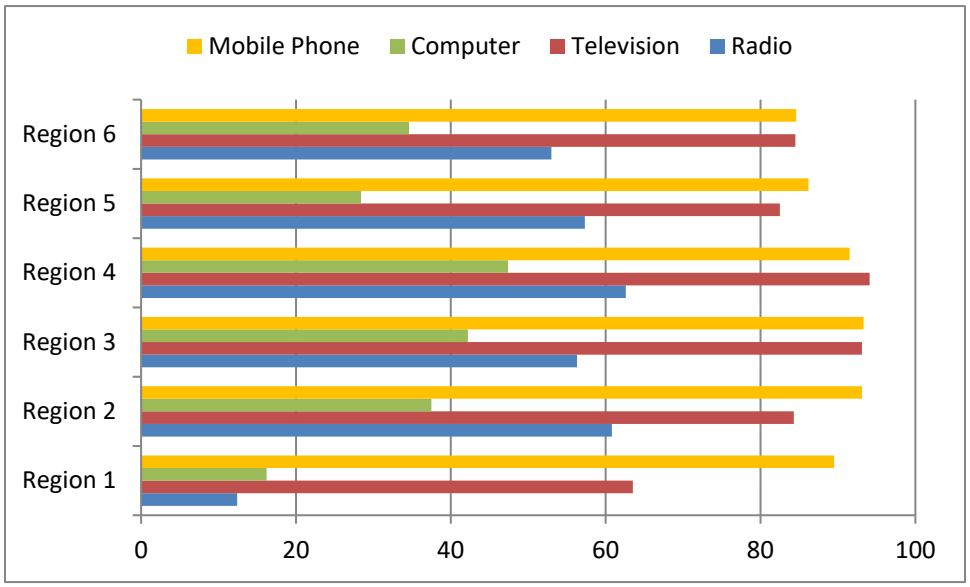


Source: UNICEF 2014

Figure 8.3-4: Percent of Population with Electricity by Region, 2014

Telecommunications

Mobile telephone coverage is quite comparable among coastal regions, and an average (across the coastal regions) of 88.6 percent of households in the country has at least one member with a mobile phone. There is more disparity in other forms of telecommunications, with Region 1 in particular showing lower levels of access to computers, television, and radio, relative to other regions (Figure 8.3-5).



Source: UNICEF 2014

Figure 8.3-5: Household Access to Telecommunications, 2014

8.3.2.4. Natural Hazards

Guyana is not threatened by many natural hazards, but due to its low-lying coastal plain, the northern areas of Regions 1 to 6 face severe risk of flooding. The INFORM risk profile for the country (Inter-Agency Standing Committee and the European Commission 2020) identifies flooding, tsunami, drought and epidemic as being the primary natural risks at the country level.

The World Bank (2016) estimates that Guyana is one of the countries most vulnerable to global climate change due to its low-lying coastal areas, as many areas lie below mean sea level and a high percentage of the population and critical infrastructure are located along the coast. In addition, Guyana's marine fisheries and food security has exhibited a high degree of vulnerability to climate-related effects (Ding et al. 2017). Both changes in rainfall patterns and predicted sea-level rise associated with climate change pose significant threats to the Guyanese population and its livelihoods. As such, the country invests consistently in the construction and maintenance of sea and river defense infrastructure, as well as a system of reclaimed lands, drainage and irrigation canals, pumping stations, and conservancy dams to protect agriculture, economic activities, and settlements in the vulnerable coastal areas. In addition, significant efforts are being made to protect and enhance natural sea defense mechanisms, in particular mangrove ecosystems. Additional discussion of climate change and its effects in relation to the Project is provided in Section 6.1, Air Quality, Climate, and Climate Change.

Despite the investment in climate change resiliency, floods continue to threaten public safety and infrastructure along the coast. One of the worst flooding crises occurred in 2005, when torrential rains caused many rivers and water conservancies in the coastal plain to overflow, causing severe flooding in Regions 1, 2, 3, 5, and 6. The floods resulted in the direct or indirect deaths of 19 people from either drowning, acute dehydration, or succumbing to an outbreak of leptospirosis that occurred in the aftermath of the flooding (PAHO 2005). Direct economic losses of agricultural crops, livestock, fisheries, forestry, and roads in the coastal area were estimated to total over $10 billion GYD (approximately $50 million USD) (ECLAC 2005). More recently, in March 2018, floodwaters breached the sea defense network in the West Coast Demerara area, damaging local businesses and homes and forcing the temporary evacuation of some residents. Annual flood damage in Georgetown is estimated to be $1.3 billion GYD ($6.5 million USD) (Guyana Times 2019).

In 2021, heavy rains in May and June resulted in serious flooding. Reports to date have indicated severe flooding in regions 10, 7, 6, 5, and 2 (CDEMA 2021). More than 36,000 households have suffered from the flooding across 300 communities in all 10 regions of the country. In the short term, the flood economic impact has included loss of livestock and agricultural production, cessation of mining activities, and the loss of mining equipment in mining regions.

8.3.3. Impact Assessment—Community Health and Wellbeing

This section assesses potential impacts from the Project's planned activities on community health and wellbeing in the Project AOI. The key potential impacts considered as a result of planned Project activities are increased risk of communicable disease transmission, decreased

public safety as a result of the presence of Project workers, increased public anxiety, and decreased availability of emergency medical and health services.

Some of the mitigation measures proposed in other EIA sections address other potential impacts on community health and wellbeing. Therefore, these potential impacts are not covered in the community health and wellbeing impact assessment. A summary of the potential impacts covered elsewhere in the EIA and the sections where they are discussed are presented in Table 8.3-5.

Table 8.3-5: Potential Impacts Discussed in Other EIA Sections and Scoped out of the Community Health and Wellbeing Impact Assessment

Potential Impact	Relevant EIA Section
Air quality emissions from Project sources	Air Quality, Climate, and Climate Change (Section 6.1)
Offshore Project activity-related discharges to water column (altering water chemistry and turbidity)	Marine Water Quality (Section 6.4)
Local job creation, contributing to positive physical and mental health outcomes	Socioeconomic Conditions (Section 8.1)
Waste generation, storage, and disposal	Waste Management Infrastructure and Capacity (Section 8.6)
Hydrocarbon spills from Project vessels operating near shore or off shore	Unplanned Events (Chapter 9)
Marine or vehicle accidents involving non-Project individuals	Unplanned Events (Chapter 9)
Workforce exposure to occupational hazards and risks	Worker Health and Safety (Section 2.15)

In determining the potential community health and wellbeing impacts of the Project, the WHO's definition of *health* was applied: "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO 2006). Factors that affect health are commonly called "determinants of health," which are defined by the International Finance Corporation (IFC 2009) as "individual, social and environmental, and institutional factors that are directly, indirectly, or cumulatively affected by the proposed project" as described in Table 8.3-6.

Table 8.3-6: Determinants of Health

Categories of Determinants of Health	Examples of Specific Health Determinants
Individual factors: genetic; biological; lifestyle; behavioral; and/or circumstantial, of which some can be influenced by proposals and plans	Gender; age; dietary intake; level of physical activity; tobacco use; alcohol intake; personal safety; sense of control over own life; employment status; educational attainment; self-esteem; life skills; stress levels; etc.
Social factors: community, economic and/or financial conditions	Access to social and health-related services and community; social support or isolation; housing; income; distribution of wealth; sexual customs and tolerance; racism; attitudes to disability; trust; sites of cultural and spiritual significance; local transport options available; etc.

Categories of Determinants of Health	Examples of Specific Health Determinants
Environmental factors: physical	Quality of air, water and soil; access to safe drinking water and adequate sanitation; disease vector breeding places; land use; urban design
Institutional factors: the capacity, capabilities and jurisdiction of public sector services	Availability of services, including health, transport and communication networks; education and employment; environmental and public health legislation; environmental and health monitoring systems; laboratory facilities; etc.

8.3.3.1. Relevant Project Activities and Potential Impacts

The Project will involve a range of activities that could potentially impact community health and wellbeing across the aforementioned categories of determinants of health. Shifts in demographic patterns, including the influx of foreign workers or the spatial concentration of working-age populations, have the potential to cause changes in disease transmission patterns, impact public safety, and increase the burden on medical and health infrastructure. The potential for these impacts is limited due to the Project's limited onshore footprint. Additionally, perceived risks and impacts associated with the oil and gas sector can also contribute to anxiety for some stakeholders; this is a concern that has emerged through stakeholder engagement activities to date, including engagement with Region 1 communities in 2021.

Table 8.3-7 summarizes the Project stages and activities that could result in potential impacts on community health and wellbeing, as well as the receptors that could potentially experience these impacts.

Table 8.3-7: Summary of Relevant Project Activities and Key Potential Impacts—Community Health and Wellbeing

Stage	Receptor(s)	Project Activity	Key Potential Impacts
All Project Stages	General population of Georgetown and vicinity	Project worker presence Project use of medical and health resources in the Georgetown area	• Increased risk of communicable disease transmission • Impacts on public safety • Overburdening of medical and health services
	General population throughout coastal communities	Overall presence of oil and gas development activities, principally related to the perceived risk of an oil spill	• Public anxiety over oil and gas sector risks

8.3.3.2. Magnitude of Impact—Community Health and Wellbeing

In the case of community health and wellbeing, there is a wide range of illnesses and disabilities already present in the population and comprising a baseline prevalence rate. However, as people value their health, even a small increase in the prevalence rate of a disease or disability that is attributed to the Project would be considered significant. The assessment of the Project's

magnitude of impacts on community health and wellbeing is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on community health and wellbeing is defined according to the definitions provided in Table 8.3-8. The following paragraphs discuss the characteristics of each of the potential impacts assessed, and the resultant magnitude ratings. These are summarized in Table 8.3-9.

Table 8.3-8: Definitions for Intensity Ratings for Potential Impacts on Community Health and Wellbeing

Criterion	Definition
Intensity	Negligible: No discernible change in health status of the population. Anticipated incidence of a health-related risk at an individual level is “very rare.”
	Low: Changes to health status occur in some individuals and households, but changes are minor, temporary, and reversible even without medical or public health intervention. Anticipated incidence of a health-related risk at an individual level is “rare.”
	Medium: Changes to health status occur at the population level, but are reversible over time or with medical or public health intervention. Anticipated incidence of a health-related risk at an individual level is “occasional.”
	High: Profound and measurable changes to health status are evident at the population level. Some health impacts may be severe or permanently debilitating, requiring medical or public health intervention or other forms of assistance for treatment and recovery. Anticipated incidence of a health-related risk at an individual level is “frequent.”

Communicable Disease Transmission

Population shifts caused by the influx of workers from other parts of the country or from foreign countries have the potential to cause changes in transmission patterns of some communicable diseases, particularly if workers originate from countries with higher rates of diseases that are transmitted person-to-person, such as TB and sexually transmitted infections. Additionally, the COVID-19 pandemic is currently affecting people in Guyana (and elsewhere) with resulting impacts on health services. As a result of the pandemic, widespread changes to business operations, inter-regional and international travel, and social interactions have been instituted in Guyana and abroad.

At this time, the countries of origin of the Project workers are primarily the United States, various European countries, and a few countries in southeast Asia, including Malaysia and the Philippines. Guyana has a lower rate of TB incidence than the global average (79 cases per 100,000 population in 2019, versus the global average of 130) but has a higher rate than most developed countries (WHO 2019). Guyana’s rate of HIV prevalence is comparable to the global average. Potential communicable disease transmission risks will vary according to the workforce’s primary countries of origin; however, as an embedded control, regardless of worker origin, the Project will establish a worker health-screening program and take precautions to avoid both internal and external communicable disease risks, including COVID-19 and other diseases.

Given the small size of the Project workforce in comparison with the receiving community (less than 1 percent of the population of Georgetown) and the Project workers’ limited onshore presence, the intensity of potential impacts on rates of communicable disease transmission is

rated as **Negligible**. Foreign workers will move through Georgetown on an **Episodic** basis (primarily before and after offshore work cycles when they are entering/leaving the country). Regardless of the intensity or frequency of foreign workers coming to Guyana, expatriate labor will constitute some portion of the Project workforce for the entire life of the Project, so the duration of the impact is rated **Long-term**. Therefore, the magnitude of potential impacts related to communicable disease transmission is rated as **Negligible**.

Impacts on Public Safety

Rapid population change and—in particular—the introduction of transient populations are often perceived as contributing to increased rates of crime. Criminal activity in Georgetown (including petty theft and armed robberies) is common. Most robberies are noted to be crimes of opportunity stemming from inadequate police presence and poor police response (OSAC 2020).

The influx of Project workers to/through the Georgetown area is not expected to contribute significantly to an increase in local crime rates. Although expatriate workers may stand out in Guyanese communities, the Project workforce will constitute less than 1 percent of the population of Georgetown, and workers' onshore presence will be limited and occasional.

Given the small size of the Project workforce in comparison with the receiving community (less than 1 percent of the population of Georgetown) and Project workers' limited onshore presence, the intensity of potential impacts on public safety is rated **Negligible**. The bulk of foreign workers will move through Georgetown on an **Episodic** basis (primarily before and after offshore work cycles when they are entering/leaving the country). Regardless of the intensity or frequency of foreign workers coming to Guyana, expatriate labor will constitute some portion of the Project workforce for the entire life of the Project, so the duration of the impact is rated **Long-term.** Therefore, the magnitude of potential impacts related to public safety is rated as **Negligible**.

Public Anxiety Regarding Oil and Gas Risks

Oil and gas represents the newest sector in Guyana's economy and concerns naturally exist among those living in coastal communities about Project activities and their perceived potential impact on livelihoods and the environment. Certain vulnerable sub-populations (e.g., indigenous populations in Region 1 coastal communities who are concerned about potential oil spills affecting the SBPA, people with existing mental health or anxiety type disorders, etc.) may be more concerned about these perceived impacts than others, and may experience an associated increase in anxiety levels.

Potential changes in health that can be attributed to Project-related anxiety are expected to be minor and reversible, especially as more Project information continues to be made available to mitigate these concerns. Recognizing that this effect is based on perception and perceptions may affect a wider area or range of people than that which could potentially be affected by physical health changes, the geographic extent of the anxiety-related impacts is predicted to be larger than other community-health related impacts (i.e., across the **Indirect AOI** rather than just the Georgetown area).

Given the small number of people who are expected to experience measurable increases in anxiety that then manifests as measurable health problems, the intensity of potential impacts on anxiety-related health indicators is rated as **Low**. These effects are predicted to occur on an **Episodic** basis over the life of the Project, and are therefore considered to be **Long-term**. As such, the intensity of Project-related impacts on public anxiety is rated magnitude of potential impacts related to public anxiety is considered **Small**.

Overburdening of Medical and Health Services

The Project will have a medical facility onboard the FPSO to treat minor medical issues. Major installation vessels will also have their own medical facilities and onboard medical professionals. In the event of more serious illness or injury that cannot be handled by the offshore medical professionals, patients will be medically evacuated to a healthcare facility in Georgetown and potentially outside of Guyana, depending on the type of medical issue. In the event an offshore worker requires medical evacuation/referral onshore, Project-dedicated medical professionals will be available offshore and onshore to support the response/referral. While these provisions will limit the degree to which Project needs will increase the burden on Georgetown medical and health services, Project use of Guyanese healthcare facilities could potentially compromise availability and access for the Guyanese local population. The Project currently uses a designated local private Guyanese clinic supported by an international medical provider, as well as hospitals in Georgetown, in the event of both work-related and non-work-related medical and health emergencies. However, for the most part, these hospitals will be relied upon only for initial evaluations or, in the case of life-threatening emergencies, stabilization before evacuation of foreign workers out of country to another facility.

Given that reliance on local Guyanese medical facilities will be limited, the intensity of the potential impact is rated as **Low**. Situations resulting in Project use of existing medical and health facilities will be **Episodic**, but the potential for such situations will extend across the life of the Project (and are therefore considered to be **Long-term**). Consequently, the magnitude of potential impacts related to Project use of medical services is considered **Small**.

Table 8.3-9: Magnitude of Impact—Community Health and Wellbeing

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
All Project Stages	General population of Georgetown and vicinity—Increased risk of communicable disease transmission	Direct AOI (Georgetown and vicinity)	Negligible	Episodic	Long-term	Negligible
	General population of Georgetown and vicinity—Impacts on public safety	Direct AOI (Georgetown and vicinity)	Negligible	Episodic	Long-term	Negligible
	General population throughout coastal communities—Public anxiety over oil and gas sector risks	Indirect AOI (Coastal communities)	Low	Episodic	Long-term	Small

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
	General population of Georgetown and vicinity—Overburdening of medical and health services	Direct AOI (Georgetown and vicinity)	Low	Episodic	Long-term	Small

8.3.3.3. Sensitivity of Receptors—Community Health and Wellbeing

The receptor sensitivity ratings for community health and wellbeing are defined in Table 8.3-10.

Table 8.3-10: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Community Health and Wellbeing

Criterion	Definition
Sensitivity	Low: The population does not have many areas of health vulnerability. Individuals and households have the personal resources and capacity to protect and promote health. The community is well equipped with resources and infrastructure to provide routine medical and health care and address medical and health emergencies. There is a predominant absence of concern regarding the impact of the Project on personal wellbeing.
	Medium: The population has multiple areas of health vulnerability, due either to environmental or social factors. Portions of the population face socioeconomic challenges that act as barriers to health protection and promotion. There are shortfalls in local medical and health resources and infrastructure that compromise ability to provide timely and appropriate medical and health care in some situations. The population contains some who express concerns regarding the impact of the Project on their wellbeing.
	High: The population has many areas of health vulnerability due to environmental and social factors. A large proportion of the population is disadvantaged, which acts as a barrier to protecting and promoting health. Adequate medical health resources and infrastructure are lacking, often not allowing for timely and appropriate medical and health care. The population contains a significant proportion of individuals who express concerns regarding the impact of the Project on their wellbeing.

The Guyanese population is in epidemiological transition whereby the burden of illness has begun to shift from communicable disease to non-communicable (chronic) diseases and injury. However, communicable diseases, including HIV/AIDS, TB, pneumonia, and others (including, more recently, COVID-19), still also make up a considerable burden of illness. This transition is characteristic of most developing countries as they experience demographic changes including lower fertility and longer life expectancy, as well as improvements in health and sanitation systems. In general, urban populations have measurably higher health status than rural populations. They have better access to health services, higher levels of immunization coverage, and are less likely to suffer from some communicable diseases such as malaria, and soil-transmitted helminths. However, densely populated urban settings, including Georgetown, are disproportionately affected by other types of communicable diseases such as dengue fever, HIV/AIDS, and TB. As such, sensitivity of the population of Georgetown to communicable disease risks is considered **Medium**.

The Guyana Police Service is responsible for maintaining security and order in the greater Georgetown area. Georgetown tends to have high-crime “hotspots,” where Guyana Police Service officials experience challenges ensuring sufficient work force and other resources. The

sensitivity of the Georgetown population to public safety-related risks is therefore considered **Medium**.

Public anxiety related to perceived impacts from oil and gas operations has been evident in isolated instances during communications with community members and during one-on-one meetings with key stakeholders. These can reasonably be expected to decrease as the local population begins to better understand the nature of the Project and the system of embedded controls to prevent unplanned events, and to experience the lack of significance of potential impacts from planned activities. For example, fisherfolk may no longer fear impacts on their livelihoods as Notice to Mariners and other communication materials show that marine safety exclusion zones do not affect their fishing zones. Continued disclosure of Project-related activities, as well as continuous engagement with the fishing community and targeted engagement with certain vulnerable populations including those coastal communities in Region 1, will help lessen anxiety.

Georgetown residents have relatively high levels of literacy and multiple means of accessing information on the Project and the country's developing oil and gas sector on a continual basis, which will help to reduce anxiety related to misconceptions about Project risks. Residents of Georgetown are also relatively well positioned to experience socioeconomic benefits of the Project, which will serve to counteract anxiety related to the Project and oil and gas sector in general. For these reasons, sensitivity of the Georgetown population to anxiety-related concerns is considered **Low**. However, as there may be some residents in other regions, including Region 1, who may still express concerns and anxieties regarding the impact of the Project on their wellbeing, the sensitivity of the population outside Georgetown is considered **Medium**.

Georgetown has a high concentration of medical and health facilities relative to other parts of Guyana, although emergency care capacity and health-related human resources are considered lacking throughout the country. Guyana's emergency medical system is in transition at this time, with a relatively new ambulance system to respond to emergencies (established in 2014), no air ambulance, and a lack of hospital beds required to adequately serve the population, although a new Infectious Diseases Hospital has been established (ERM Personal Communication 7). Given these health system gaps in several critical areas, sensitivity to health services impacts is considered to be **Medium**.

8.3.3.4. Impact Significance—Community Health and Wellbeing

Based on the magnitude of impact and receptor sensitivity ratings, the significance of increased potential impacts on community health and wellbeing are rated as **Negligible** for communicable disease transmission and public safety, and **Minor** for public anxiety and overburdening of medical health services.

8.3.4. Management Measures—Community Health and Wellbeing

Given the **Negligible** significance of potential impacts on community health and wellbeing for communicable disease transmission and public safety, mitigation measures are not required. That said, EEPGL is committed to working closely with police and other public safety authorities

as needed to address concerns regarding Project linkages to these types of impacts. With respect to public safety concerns, EEPGL will require Project workers to adhere to a worker code of conduct, including when they are onshore (residents, visitors, transits). With respect to public anxiety concerns, EEPGL's ongoing stakeholder engagement programs and oil spill response training programs will continue to provide means of informing the community about the Project; this is expected to contribute to decreasing public anxiety about perceived Project risks, including in Region 1. Although this sensitivity is expected to decrease over time as the country becomes more accustomed to the presence of the oil and gas industry, it may not be possible to alleviate concerns across the entire population.

With respect to potential impacts on community health and wellbeing related to overburdening of medical facilities due to Project use, EEPGL has reduced the magnitude of this potential impact to the extent reasonably practicable (i.e., through the embedded control of having trained medical personnel on board the FPSO and major installation vessels to minimize reliance on medical infrastructure and facilities in Guyana). In addition, the Project will use an international medical provider to complement the services of the local private medical clinic used by the Project, and will procure a dedicated ambulance to avoid overwhelming the local medical infrastructure. Table 8.3-11 summarizes the embedded controls, mitigation measures, and monitoring measures relevant to this receptor.

Table 8.3-11: List of Embedded Controls, Mitigation Measures, and Monitoring Measures

Embedded Controls
Provide health-screening procedures to Project workers to reduce risks of transmitting communicable diseases.
Develop and implement a Stakeholder Engagement Plan.
Implement a transparent, accessible, and consistent Community Grievance Mechanism (CGM) early on, prior to onset of Project activities. Ensure CGM is well publicized and understood by the public.
Monitor grievances received and resolved by the CGM; adjust CGM and other management measures, as appropriate.
Implement a community safety program for potentially impacted schools and neighborhoods to increase awareness and minimize potential for community impacts due to vehicle incidents.
Mitigation Measures
Require Project workers to adhere to a Worker Code of Conduct, which will address shore-leave considerations.
Use a dedicated medical provider to complement the services of the local private medical clinic used by the Project, and procure a dedicated ambulance to avoid overwhelming the local medical infrastructure (ambulance has already been procured as of the writing of this EIA).
Monitoring Measures
Track number and types of complaints received via the Project CGM.
Monitor average time for processing and resolution of grievances.
Track percentage of grievances resolved.
Monitor Project workers' occupational exposure to sound.
Test for diseases that are communicable through normal medical screening/surveillance.
Monitor frequency of engagement with stakeholders, including fisherfolk, coastal communities, vulnerable groups, and indigenous populations

Table 8.3-12 summarizes the assessment of potential pre-mitigation and residual Project impacts on community health and wellbeing. The significance of impacts was assessed based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the community health and wellbeing-specific methodology described in Sections 8.3.3.2 and 8.3.3.3.

Table 8.3-12: Summary of Potential Pre-Mitigation and Residual Impacts—Community Health and Wellbeing

Stage	Resource/Receptor Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	**Social Factors**					
	General population of Georgetown and vicinity—increased risk of communicable disease transmission	Medium	Negligible	Negligible	None	Negligible
	General population of Georgetown and vicinity—impacts on public safety	Medium	Negligible	Negligible	Worker code of conduct, including when workers are onshore	Negligible
	Individual Factors					
	Public anxiety over oil and gas sector risks, including perceived impacts associated with oil spills and seismic events	Georgetown Low Outside Georgetown Medium	Small	Georgetown Negligible Outside Georgetown Minor	None	Georgetown Negligible Outside Georgetown Minor
	Institutional Factors					
	General population of Georgetown and vicinity—reduced access to emergency and health services	Medium	Small	Minor	Onshore medical provider with international medical provider support, and dedicated ambulance	Minor

8.4. MARINE USE AND TRANSPORTATION

8.4.1. Administrative Framework—Marine Use and Transportation

Table 8.4-1 summarizes the legislation, policies, or treaty commitments that are specifically relevant to the assessment of potential impacts on marine use and transportation.

Table 8.4-1: Legislation, Policies, or Treaty Commitments—Marine Use and Transportation

Title	Objective	Relevance to the Project
Legislation		
Guyana Shipping Act (1998) Cap. 49:01.	Establishes the framework for the regulation of vessels and sets out MARAD and its functions.	MARAD is the principal regulator for vessels operating in the marine environment and all vessels associated with the Project operating within Guyana waters will fall under the purview of MARAD.
Maritime Zones Act (2010) Cap. 63:01.	Incorporates certain provisions of the United Nations Convention on the Law of the Sea and the United Nations Educational, Scientific and Cultural Organization Convention on the Protection of the Underwater Cultural Heritage, to provide for marine scientific research, maritime cultural area, eco-tourism, marine parks and reserves and mariculture, the protection and preservation of the marine environment and for related matters.	Provides for rights and regulation of activities within the various maritime zones, including the territorial sea and exclusive economic zone, and addresses the protection and preservation of the marine environment, including pollution.
International Agreements Signed/Acceded by Guyana		
International Convention for the Safety of Life at Sea (1974) (Guyana acceded in 1997)	Specifies minimum standards for the construction, equipment, and operation of vessels with respect to their safety; allows governments of participating states to inspect vessels flagged in other participating states to ensure compliance.	Affects construction, operation, and equipment on board the drill ships, FPSO, installation vessels, and support vessels.
Convention on the International Regulations for Preventing Collisions at Sea (1972) (Guyana acceded in 1997)	Officially recognizes the importance of traffic separation in the marine environment and codifies basic measures to accommodate traffic separation, including safe speed, signalling conventions, and general vessel conduct.	Governs maritime operation of drill ships, FPSO, installation vessels, and support vessels.
International Convention on Standards of Training,	Obligates crews operating vessels flagged in signatory states to adhere to minimum standards	Applies to required capabilities of crew on board the drill ships, FPSO, installation vessels, and

Title	Objective	Relevance to the Project
Certification and Watchkeeping (1978) (Guyana acceded in 1997)	relating to training, certification, and watchkeeping; requires signatory states to submit detailed information to the International Maritime Organization concerning administrative measures taken to ensure compliance with the convention.	support vessels, and provides for inspection by authorities to ensure compliance.
Convention on Facilitation of International Maritime Traffic (1965) (Guyana acceded in 1998)	Prevents unnecessary delays in maritime traffic arising from burdensome documentation requirements and establishes uniform formalities and other procedures to permit transboundary maritime commerce and travel.	Facilitates entry of drill ships, FPSO, installation vessels, and support vessels into Guyana.

8.4.2. Existing Conditions—Marine Use and Transportation

This section describes Guyana's existing marine and coastal transportation infrastructure, with particular focus on the Project AOI. Data and information in this section were obtained from key informant interviews, reports, studies, and other publicly available information, as well as direct observations of vessel activity in Georgetown Harbour.

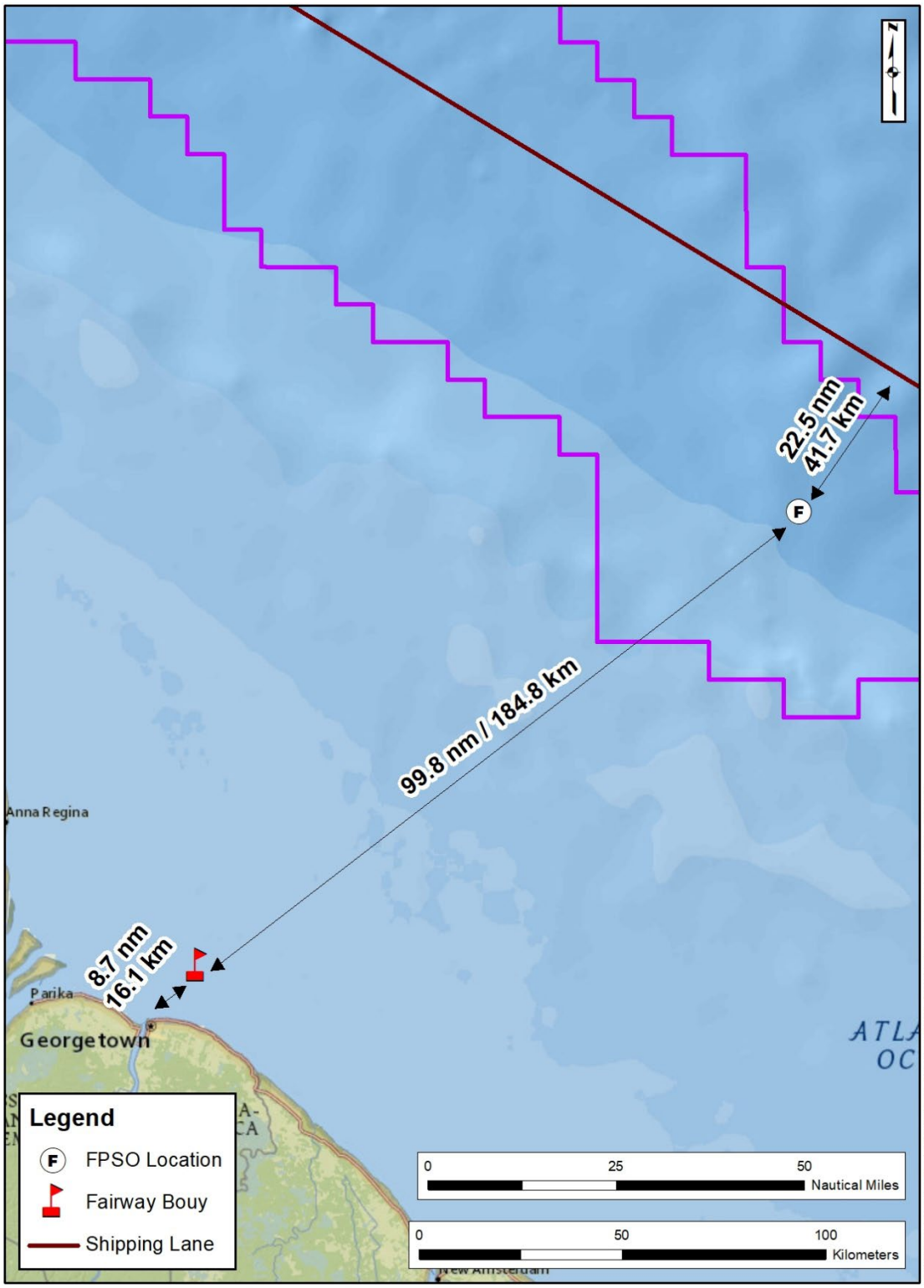
8.4.2.1. Regional Setting

The Environmental Protection Act requires EIAs to assess impacts on material assets. Nearly all the Project-related activities will occur at designated shorebases on the coast, in coastal marine waters, or offshore. Therefore, for the purposes of this EIA, "material assets" include marine infrastructure within the Project AOI, which consists of waterways, coastal shipping channels, ports, and offshore shipping lanes. Guyana has approximately 1,000 kilometers (approximately 620 miles) of navigable rivers, which provide water access to most population and economic centers. Subsea telecommunications cables are also present in the Project AOI.

8.4.2.2. Existing Conditions in the Project Area of Influence

Marine Transportation

MARAD is responsible for ensuring the safe and efficient operation of shipping activities in Guyana territorial waters. Representatives from MARAD have advised EEPGL that Jamaican and Trinidadian shipping lanes cross the Stabroek Block. Figure 8.4-1 shows the location of the identified shipping lane in the Stabroek Block, as indicated on the pilot chart for the Caribbean and Gulf of Mexico.



km = kilometer; nm = nautical miles

Figure 8.4-1: Proximity of Proposed Yellowtail FPSO Location to Offshore Shipping Lanes

As described in Section 8.1.2.4, Economic Conditions, fisheries are of significant importance to Guyana's economy, particularly in coastal areas. Marine fisheries and subsistence fishing occur throughout Guyana coastal waters, from the shore to the edge of the continental shelf, approximately 150 kilometers (approximately 93 miles) from shore, although most fishing activity occurs well inshore from the edge of the continental shelf. Deep-sea pelagic fishing commenced in 2016 and, according to personnel from the Fisheries Department, expanding deep-sea fishing is an important long-term objective for the fisheries sector. In addition, the Fisheries Department can license vessels to fish outside Guyana's territorial waters, and is exploring how this industry can be developed (ERM/EMC Personal Communication 4). Figure 8.4-2 depicts the primary fishing zones offshore Guyana, by fishery type, and the primary fishing ports or fish landing sites in Regions 1 through 6.

The Port of Georgetown contains more than 40 separate wharves, including six primary cargo wharves, ranging from approximately 127 to 247 meters [approximately 417 to 810 feet] in length, with depths alongside ranging from 4.8 to 7.4 meters [15.7 to 24.3 feet], as well as four tanker berths, with depths of 3.1 to 6.7 meters [10.2 to 22.0 feet] alongside. Rome Terminal, with a wooden T-head pier about 35 meters (115 feet) in length, is situated just south of Houston. It is used for the discharge of petroleum products, including liquefied petroleum gas, and has an alongside depth of 3.5 meters (11.5 feet). The Demerara Harbour Bridge, located 3.2 kilometers (2 miles) upstream from Georgetown, is a low-lying pontoon bridge with two central retraction sections that provide a 77-meter (252.6-foot)-wide opening for passage. The highest clearance available without retracting any section is 7.9 meters (25.9 feet) (NGIA 2017). Other privately owned docks and portside facilities near Georgetown and the mouth of the Demerara River have staging areas or storage yards, although these facilities are congested and space is limited.

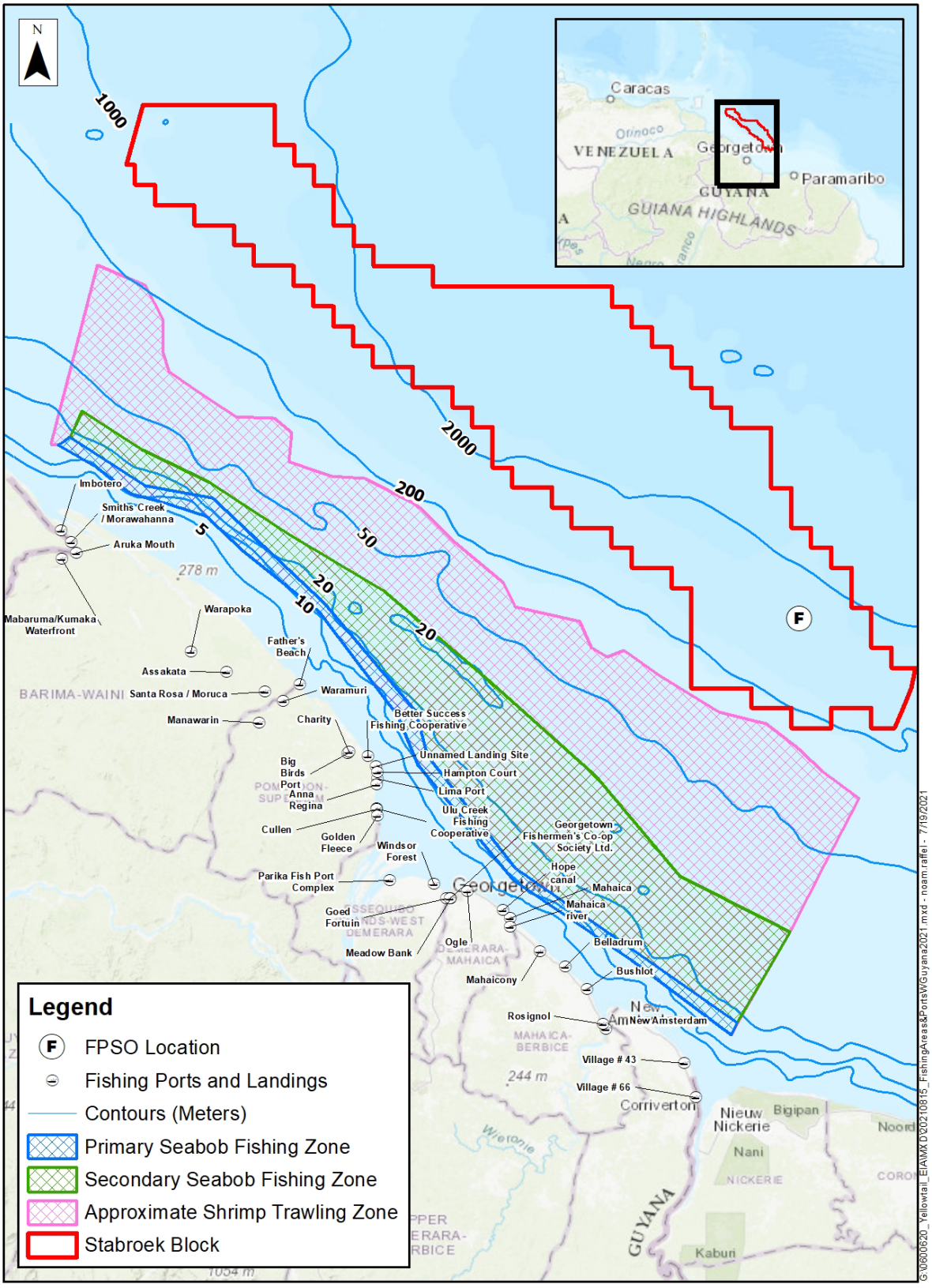


Figure 8.4-2: Fishing Zones and Main Fish Landing Sites and Ports

A shipping channel is maintained on the lower Demerara River for the use of private, commercial, and military vessels. Pilotage is presumed to be required to access the channel, and is provided by the Harbour Master. However, the Chief Pilot recently indicated that due to a shortage of pilots, he has been allowing vessels who have intimate knowledge of the harbor as well as the channel to leave and enter the harbor without pilots (Gonsalves 2021b). Vessels arrive in or depart from the Port of Georgetown in the vicinity of the Fairway Buoy, which is located approximately 8.7 nautical miles (16.1 kilometers) from the port (Figure 8.4-1). Departing vessels then proceed eastward or westward of the buoy depending on the destination port. The Demerara River channel has a dredged depth of 5.7 meters (slightly under 19 feet), and has historically been dredged weekly to maintain this depth (ERM Personal Communication 27; Gonsalves 2021c).

From 16 April to 30 April 2018, a study was undertaken to record vessel traffic in Georgetown Harbour between the mouth of the harbor and an existing shorebase that is planned to be used by the Project. Observations were made from two locations: one at the Kingston Outfall Channel near the mouth of the harbor, and one at the Quick Shipping Wharf (Figure 8.4-3). Observations were made on a 24-hour basis, recording the time of day, type of vessels observed, and direction of travel.

Table 8.4-2 summarizes the vessel traffic recorded during this period. Almost 1,800 vessel movements were counted at the Kingston Outfall observation location, yielding an average of 126 vessels per day. More than 2,100 vessel movements were recorded at the Quick Shipping Wharf observation location, yielding an average of 153 vessels per day. The Quick Shipping Wharf count included 178 east-west movements across the harbor, primarily from speedboat trips, small private boats, and barges travelling across the river. Many of the vessels movements were “linked,” meaning they were counted at both locations during the same movement (i.e., as they passed them successively). While some of these instances were definitively linked, the difficulty in accomplishing this linking (in particular at night) prevents a precise count of these instances.

Fishing vessels accounted for most of the marine traffic. At the Kingston Outfall observation location, 76 percent of vessel movements were either trawlers or other kinds of fishing boats. At the Quick Shipping Wharf observation location, fishing boats and trawlers accounted for 71 percent of the traffic, while passenger boats and “other” vessels (primarily small, private boats) made up 11 percent of the traffic. Larger vessels, including ocean-going vessels, coastal vessels, and oilfield service vessels, comprised a higher proportion of the vessel traffic at the Kingston Outfall observation location, totaling 14 percent of the vessels counted at this location.

Figure 8.4-3: Georgetown Harbour Vessel Observation Points (16–30 April 2018) and Speedboat Stellings

Table 8.4-2: Vessel Traffic Observed in Georgetown Harbour, 16–30 April 2018

	Kingston Outfall Channel			Quick Shipping Wharf [a]				
Vessel Type	**Northbound (Outbound)**	**Southbound (Inbound)**	**Total**	**Northbound (Outbound)**	**Southbound (Inbound)**	**Eastbound (across channel)**	**Westbound (across channel)**	**Total**
Oceangoing (cargo, tanker, etc.)	42	59	101	38	32	1	1	72
Coastal vessel	51	70	121	34	33	1	4	72
Oilfield service vessel	12	12	24	12	11			23
Tug and barge	31	27	58	23	24	18	17	82
Tug alone	20	20	40	1	4			5
Trawler	195	204	399	155	155	1	1	312
Fishing vessel (other than trawler)	484	454	938	617	566	13	17	1,213
Government vessel (Coast Guard, police, Guyana Revenue Authority, harbor boat)	7	8	15	21	26	7	9	63
Pilot boat	26	34	60	32	37	1	1	71
Passenger boat (speedboat)	0	0	0	17	13	26	27	83
Other vessel	5	3	8	56	62	14	19	151
Total	873	891	1,764	1,006	963	82	96	2,147

[a] In addition, the Quick Shipping Wharf site counted 73 movements in which a Coast Guard vessel moved out of its dock and into the channel, and then immediately returned to dock. These are not included in the counts in this table.

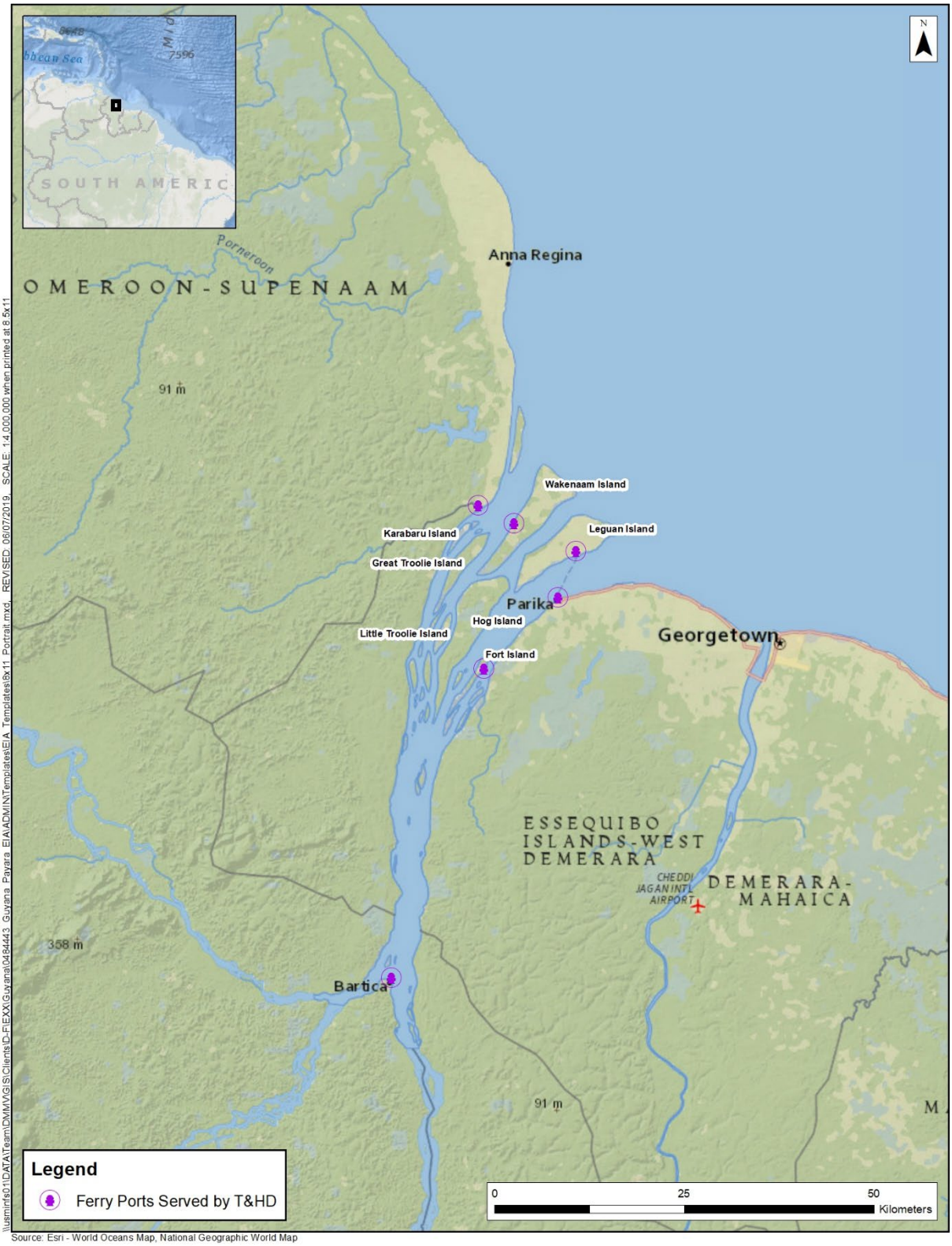
Marine traffic activity was nearly continuous throughout each day. The highest volumes of marine traffic consistently occurred between 9:00 a.m. and 6:00 p.m. daily, although other times were also quite active. From 10:00 p.m. until 6:00 a.m., local fishing boats made up 78 percent of the marine traffic observed from the Quick Shipping Wharf location.

Day-to-day variations, particularly in fishing vessel movements, resulted from tides and weather. The local fishing boats tend to go to sea on a rising tide so that they can set their nets at the high tide, and return with their catch when the tide is falling. The observations period included a neap tide that resulted in lower volumes of fishing boats during the middle of the counting period, from 21 to 25 April. Tidal conditions resulted in high traffic volumes during some night or early morning hours.

The Transport and Harbours Department is responsible for the management of the national ferry service. The Department has seven ferry vessels currently operating. Two of the ferries operate the “Northwest route,” which travels between Georgetown (Region 4) and Region 1. Four ferries are currently operating in the Essequibo River from several ports (also known as stellings) on either side of the Essequibo River, on Leguan and Wakenaam Islands, and at Bartica, as shown on Figure 8.4-4. A seventh ferry has been transferred to Moleson Creek for use at the Suriname border, but this ferry service was not open at the time of writing of this EIA (Chin 2021).

In addition to the national ferry service, many smaller vessels provide transportation between Regions 2 and 3 across the Essequibo River, as well as across the Demerara River, between the Stabroek Market stelling in Georgetown (Region 4) and Vreed-en-Hoop stelling (Region 3) on the west bank of the river. These smaller vessels are collectively and informally known as “speedboats” because they typically travel faster than the ferries. These speedboats vary in size, power, and capacity, but can typically carry from 13 to 30 passengers. Across the Essequibo River, speedboats operate at the same ports as the national ferry service, and may also call at smaller informal landings as clients demand and conditions warrant.

Speedboats are an important element in the transportation system between Georgetown and West Demerara. Speedboats serving the Demerara River crossing operate from 6:00 a.m. to 8:00 p.m. There are 58 speedboats registered with the Speedboat Association, of which 50 to 53 are operational on any given day (Gonsalves 2021a.). Registered Demerara River speedboats generally share a common design, with a legal capacity of 33 passengers in a covered compartment, plus two crewmembers. Monitors at the Vreed-en-Hoop and Stabroek Market stellings record speedboat crossings and are meant to ensure that registered boats adhere to a set of rules developed by the Speedboat Association. The locations of the speedboat stellings on the Demerara River are shown on Figure 8.4-3. Rules and regulations for the safe operation of speedboats are developed by MARAD and enforced with the assistance of the Speedboat Association. The Speedboat Association has also developed and enforces a disciplinary system that requires registered speedboats to take turns, and also requires passengers to be seated and wearing a life vest before the boat casts off from the dock (Gonsalves 2018).



T&HD = Transport and Harbours Department

Figure 8.4-4: Essequibo River Ferry Terminals

During the morning rush period, at least five speedboats load simultaneously at Vreed-en-Hoop and discharge at Stabroek. Table 8.4-3 summarizes 2017 speedboat passenger volumes. Passenger volumes are substantially lower on Saturdays and Sundays. In 2017, approximately 590 school children commuted daily from Vreed-en-Hoop to Georgetown. This represented a 5 percent increase over 2016.

Table 8.4-3: 2017 Stabroek Market Weekday Speedboat Passenger Activity

Vessel Type	All Weekdays	Mondays
Average daily disembarkations	9,233	10,211
Rush hour (0600–0900 hours) disembarkations	5,225	5,808
Afternoon embarkations	1,815	ND

Source: Gonsalves 2018

ND: No data available

Telecommunications

A Guyana Telephone & Telegraph subsea telecommunications cable, which is part of the Suriname Guyana Submarine Cable System (SGSCS), runs through the Stabroek Block, but is outside of the PDA. Figure 8.4-5 shows the mapped route of the SGSCS compared to the planned location of the Yellowtail Development Project FPSO. Since the SGSCS is outside the PDA, planned Project activities will not interact with it; accordingly, the SGSCS is not discussed further in this EIA.

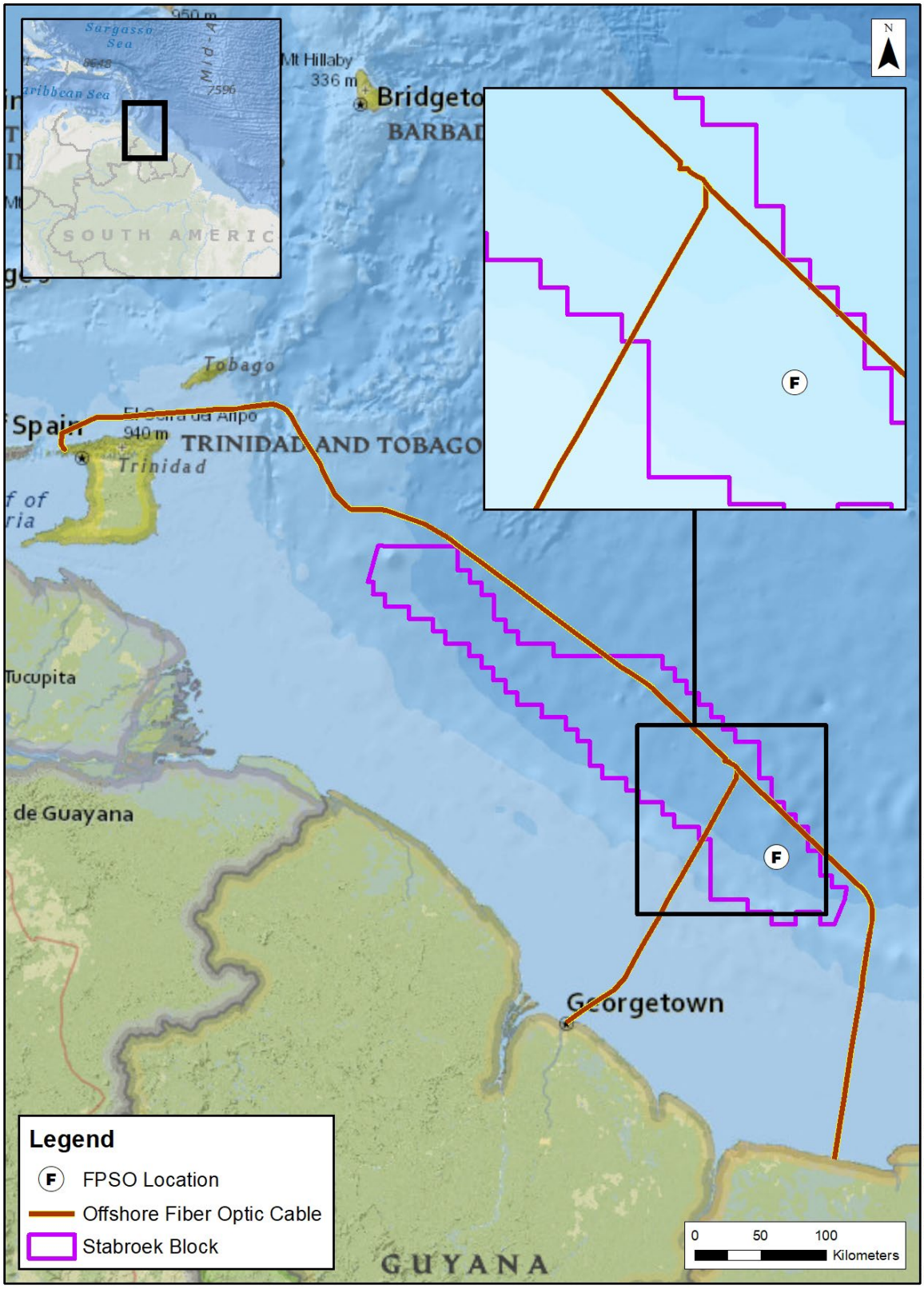


Figure 8.4-5: Mapped Route of SGSCS in Relation to Yellowtail FPSO

8.4.3. Impact Assessment—Marine Use and Transportation

This section assesses potential Project impacts on marine use and transportation in the Project AOI. The Project will involve the drilling of development wells, installation, commissioning, start-up, and long-term operations of an FPSO and SURF, and transit of Project support vessels between the PDA and the Guyana shorebases, as well as between the PDA and shorebases in Trinidad and Tobago. The assessment of potential impacts on marine use and transportation from these Project activities was based on the following assumptions:

- Most Project support vessel trips will originate from (and return to) shorebase facilities in Georgetown and shorebase facilities in Trinidad and Tobago.
- The development well drilling stage for the Project could potentially use up to two drill ships on station simultaneously, with occasional short-term periods (i.e., several months) when a third drill ship could potentially be used to drill one to two wells on an opportunistic basis.

8.4.3.1. Relevant Project Activities and Potential Impacts

The FPSO will be anchored to the seafloor for the duration of the production operations stage, which is planned to last at least 20 years. During this stage, the FPSO will have a 2-nautical-mile (3.7-kilometer) radius marine safety exclusion zone (covering approximately 4,300 hectares [10,600 acres]), in which no unauthorized vessels will be allowed to enter during offloading of crude oil from the FPSO to export tankers. In addition, the drill ships will each have a 500-meter (1,640-foot) radius marine safety exclusion zone during drilling operations and well workovers, and a 500-meter (1,640-foot) radius marine safety exclusion zone will be maintained around each major installation and decommissioning vessel during the installation and decommissioning stages, respectively. Notices to mariners will be issued via MARAD to the Trawler's Association and fishing co-ops for planned Project marine vessel movements, including the FPSO, drill ships, and major installation/decommissioning vessels. Additionally, through the stakeholder engagement process, EEPGL will also communicate plans for major Project vessel movements to commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners, to aid them in avoiding Project vessels.

Based on current drilling activities and past experience with similar developments, it is estimated that the Project will generate a variety of marine support vessel trips throughout the Project life. Support vessel activities will consist of:

- Multi-purpose vessels supporting subsea installation and maintenance activities;
- Multiple supply vessels conducting re-supply trips to the drill ships;
- Multiple supply vessels conducting re-supply trips to the FPSO during operations;
- Vessels conducting vessel-to-vessel fuel bunkering;
- Tug vessels supporting tanker offloading activities; and
- Multi-purpose vessels supporting decommissioning activities.

The following vessel trips to or from a Guyana or Trinidad and Tobago shorebase are estimated based on past and ongoing exploration drilling activities, development drilling activities, SURF installation activities for previously approved development projects, and more than 18 months of operating experience with the Liza Destiny FPSO:

- During development drilling (assuming two drill ships are supporting Yellowtail), support vessels could average approximately 12 to 15 trips per week to or from shorebases.
- During installation, commissioning, and start-up, support and installation vessels could average approximately three to five trips per week to or from shorebases.
- During the production operations stage, support vessels could average approximately three to five trips per week to or from shorebases.

As described in Section 2.12, End of Yellowtail Operations (Decommissioning), EEPGL has not prepared detailed plans for the decommissioning stage. As such, the number of vessel trips associated with decommissioning cannot be reliably estimated at this time. For the purposes of the impact analysis, vessel traffic associated with Project decommissioning is assumed to be similar to that for the combined drilling and installation, commissioning, and start-up activities (i.e., on the order of approximately 15 to 20 vessel trips per week to or from shorebases, assuming two drill ships are active during decommissioning).

For the purposes of the impact assessment, marine safety exclusion zones are considered an embedded control (i.e., part of the Project design). Accordingly, the “pre-mitigation” impact significance ratings consider the inclusion of this measure.

Table 8.4-4 summarizes the Project stages and activities that could result in potential Project impacts on marine use and transportation, as well as the receptors that could potentially experience these impacts.

Table 8.4-4: Summary of Relevant Project Activities and Key Potential Impacts—Marine Use and Transportation

Stages	Receptor(s)	Project Activity	Key Potential Impacts
Development Well Drilling SURF/FPSO Installation, Commissioning, and Start-up	• Commercial cargo vessels • Commercial fishing vessels • Subsistence fishing vessels	Maritime transport of Project materials, supplies, and personnel	Increased vessel traffic in Georgetown Harbour, coastal waters between Georgetown and the PDA, and along transit routes leading to Georgetown
	• Commercial cargo vessels • Commercial fishing vessels	Presence of FPSO, drill ships, and major installation vessels	Reduced availability of ocean surface areas for non-Project activities due to marine safety exclusion zones around the FPSO, drill ships, and major installation vessels
Production Operations	• Commercial cargo vessels	Maritime transport of Project materials, supplies, and personnel	Increased vessel traffic in Georgetown Harbour, coastal waters between

Stages	Receptor(s)	Project Activity	Key Potential Impacts
	• Commercial fishing vessels • Subsistence fishing vessels		ports and the PDA, and along transit routes leading to Georgetown
	• Commercial cargo vessels • Commercial fishing vessels	Presence of FPSO, tanker, drill ships, and workover vessel	Reduced availability of ocean surface areas for non-Project activities due to marine safety exclusion zones around the FPSO, tanker, drill ships, and workover vessels
Decommissioning	• Commercial cargo vessels • Commercial fishing vessels • Subsistence fishing vessels	Maritime transport of Project materials, supplies, and personnel	Increased vessel traffic in Georgetown Harbour, coastal waters between ports and the PDA, and along transit routes leading to Georgetown
	• Commercial cargo vessels • Commercial fishing vessels	Presence of decommissioning vessels	Reduced availability of ocean surface areas for non-Project activities due to marine safety exclusion zones around major decommissioning vessels

8.4.3.2. Magnitude of Impact—Marine Use and Transportation

The assessment of the Project's magnitude of potential impacts on marine use and transportation is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on marine use and transportation is defined according to the definitions provided in Table 8.4-5. The following paragraphs discuss the characteristics of each of the potential impacts assessed and the resultant magnitude ratings. These are summarized in Table 8.4-6.

Table 8.4-5: Definitions for Intensity Ratings for Potential Impacts on Marine Use and Transportation

Criterion	Definition
Intensity	Negligible: No discernible change in transportation activity, waterway congestion, or demands on other infrastructure.
	Low: Increased transportation activity or marine infrastructure demand may be perceptible, but does not significantly impact the capacity of waterways or transportation infrastructure.
	Medium: Increased transportation activity or marine infrastructure demand is widely perceptible and noticeably reduces waterway or transportation infrastructure capacity, but impacts do not require a change in typical travel behavior by non-Project marine users.
	High: Increased transportation activity or marine infrastructure demand is significant and causes substantial delay or congestion on waterways, to the point where vessel operators or other users of infrastructure must consistently and frequently change their typical daily behavior.

Increases in Marine Traffic and Resultant Impacts to Navigation

The Project's marine activities will potentially impact vessel traffic into and out of Georgetown Harbour, open-ocean shipping in the vicinity of the PDA, the limited commercial fishing activity that occurs as far out as the PDA, and commercial and subsistence fishing activity within the portion of the AOI that connects the PDA to Georgetown Harbour and to shorebases in Trinidad. As described above, Project-related vessel traffic will be higher during the development well drilling stage than during the production operations stage.

The Harbour Master has advised EEPGL that Jamaican and Trinidadian vessel shipping lanes cross the Stabroek Block (ExxonMobil Personal Communication 1). As such, commercial shipping traffic could potentially pass within some proximity of the PDA. However, shipping lane maps indicate the FPSO will be more than 22.5 nautical miles (41.7 kilometers) from the nearest generalized shipping lane (see Figure 8.4-1). More importantly, the shipping lanes in question are traditional, and are not precisely demarcated. Accordingly, even if Project vessels are in close proximity to mapped lanes, shipping lane users will have ample warning and space to navigate, and there is no reason to believe Project activities in the PDA will meaningfully impede non-Project shipping traffic. No interference with shipping traffic has been reported during previous seismic surveys or exploration drilling activities.

The highest potential for interactions between non-Project vessels and Project vessels in Guyana waters is near Georgetown Harbour and the Demerara River mouth, where vessel traffic is already concentrated and has been increasing based on continuing development in the harbor. The Project's potential impacts on marine use and transportation for subsistence activity are likely to be limited, but challenges in communicating with the subsistence fishing fleet may limit the effectiveness of efforts to advise the fleet of Project operations. The potential social and economic impacts of the Project's marine safety exclusion zones on commercial and subsistence fishing and recommendations to manage these impacts are described in Sections 8.1.3, Impact Assessment—Socioeconomic Conditions, and 8.2.3, Impact Assessment—Employment and Livelihoods.

During development well drilling and again during decommissioning, the Project could generate on the order of one to three additional daily vessel departures from or arrivals to the Port of Georgetown or Trinidad and Tobago. Based on the vessel surveys summarized in Section 8.4.2, Existing Conditions—Marine Use and Transportation, even assuming that all of these departures/arrivals occur in the Port of Georgetown, this frequency of activity is a small fraction of the existing vessel activity in the Port of Georgetown. Additionally, Project support vessels will typically be smaller and more maneuverable than the cargo or tanker vessels that call on the Port of Georgetown, further supporting the conclusion that Project vessels will not present significant incremental navigation hazards within or near this port.

Considering the information presented above, potential impacts related to increased marine traffic and resultant impacts to navigation will be limited to primarily the **Direct AOI** and a small portion of the **Indirect AOI** leading from the PDA to Trinidad. Conservatively assuming that all port calls occur in Georgetown Harbour, Project-related vessel activity in Georgetown Harbour—at the stage where development well drilling and FPSO operations are happening

concurrently—will increase the existing marine traffic in Georgetown Harbour by approximately 2 to 4 percent. On this basis, the intensity of the potential impacts to marine traffic is rated as **Low**. Project-related marine traffic will occur on a routine basis continuously throughout the Project life cycle, yielding a frequency designation of **Continuous** for all stages. The duration will be **Long-term** for drilling; installation, commissioning, and start-up; and production operations stages and **Medium-term** for the decommissioning stage. This yields a magnitude rating of **Small** for potential impacts on marine traffic and resultant impacts to navigation.

Loss of Use of Marine Safety Exclusion Zones

Vessels transiting the PDA will need to avoid the marine safety exclusion zones around the drill ships, major installation or decommissioning vessels, and the FPSO. During periods of crude oil offloading to export tankers, the FPSO marine safety exclusion zone will require non-Project vessels to avoid approximately 4,300 hectares (approximately 10,600 acres) (approximately 0.2 percent) of the Stabroek Block's approximately 2.7 million hectares (approximately 6.7 million acres) for at least 20 years. Because the FPSO will be anchored to the seafloor, its marine safety exclusion zone will essentially be a permanent navigation feature until the Project components are decommissioned. The total marine safety exclusion zone around each drill ship will be comparatively smaller (approximately 79 hectares [195 acres]) per drill ship, and the zone around each drill ship will be in force only during development drilling activities, which is anticipated to last up to 7 years, and occasionally during well workover activities in later years. Similar-sized marine safety exclusion zones around major installation vessels will occur only during the FPSO/SURF installation stage, or in the event repairs or maintenance are required.

Fishing vessels near the PDA will lose use of the defined marine safety exclusion zones for fishing activities. As described in Section 8.1.2, Existing Conditions—Socioeconomic Conditions, and Section 8.2.2, Existing Conditions—Employment and Livelihoods, most subsistence fishing occurs in nearshore areas and most commercial fishing occurs between the coast and the edge of the continental shelf (i.e., shoreward of the PDA). As described in Section 8.2.3.2, Magnitude of Impact—Employment and Livelihoods, there is only one commercial fishing company, with 12 vessels based on the most recent information collected, that engages in deepwater tuna fishing that may approach the southern boundary of the PDA, and abandoned fishing gear has been found entangled in the mooring lines for metocean instruments installed by EEPGL in the same area. There are also reportedly Venezuelan vessels that fish on occasion at distances as far out as 190 kilometers (118 miles) from shore, but no further information about Venezuelan fishing activity on the outer continental shelf or slope is available. If deepwater fishing continues to develop in the vicinity of the PDA, the number of industrial fishing vessels affected by Project-related activities offshore may increase modestly in the future, but would still be a relatively small amount of vessels compared to the overall fishing fleet in Guyana.

With respect to commercial fishing, most of the PDA is in waters deeper than those used most often for commercial fishing, and in any case the size of the FPSO marine safety exclusion zone is insignificant relative to the area available for fishing. As a result, the Project's potential

impacts on marine use and transportation for current commercial fishing activities also are likely to be limited.

Impacts related to loss of the use of the marine safety exclusion zones by non-Project marine users will be limited to a portion of the **Direct AOI** (i.e., a portion of the PDA). While the amount of area affected will be less than 1 percent as compared to the available marine waters in the Guyana Exclusive Economic Zone, the fact that the marine safety exclusion zones will represent essentially permanent avoidance areas results in an intensity rating of **Low**. The marine safety exclusion zones will be in place throughout all stages, yielding a frequency designation of **Continuous** for all stages. Duration will be **Long-term** for drilling; installation, commissioning, and start-up, and production operations phases and **Medium-term** for the decommissioning stage. Therefore, the magnitude of this potential impact is rated as **Small**.

Table 8.4-6: Magnitude of Impact—Marine Use and Transportation

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Development Well Drilling SURF/FPSO Installation, Commissioning, and Start-up	Commercial vessels (cargo and fishing) and subsistence fishing vessels—increased traffic and resultant impacts on navigation	Direct AOI (Georgetown Harbour, PDA)	Low	Continuous	Long-term	Small
	Commercial vessels—Reduced availability due to marine safety exclusion zones	Direct AOI (PDA)	Low	Continuous	Long-term	Small
Production Operations	Commercial vessels (cargo and fishing) and subsistence fishing vessels —increased traffic and resultant impacts on navigation	Direct AOI (Georgetown Harbour, PDA)	Low	Continuous	Long-term	Small
	Commercial vessels—Reduced availability due to marine safety exclusion zones	Direct AOI (PDA)	Low	Continuous	Long-term	Small
Decommissioning	Commercial vessels (cargo and fishing) and subsistence fishing vessels—increased traffic and resultant impacts on navigation	Direct AOI (Georgetown Harbour, PDA)	Low	Continuous	Medium-term	Small
	Commercial vessels—Reduced availability due to marine safety exclusion zones	Direct AOI (PDA)	Low	Continuous	Medium-term	Small

8.4.3.3. Sensitivity of Receptors—Marine Use and Transportation

Potential receptors for marine use and transportation impacts include current users of Georgetown Harbour and Guyanese coastal and offshore waters. The receptor sensitivity ratings for marine use and transportation are defined in Table 8.4-7.

Table 8.4-7: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Marine Use and Transportation

Criterion	Definition
Sensitivity	Low: The receptor is accustomed to or specifically anticipates the type of activity proposed by the Project; existing transportation activities can easily adapt to additional transportation activity with no outside assistance or mitigation.
	Medium: The receptor is not specifically accustomed to the type of activity proposed by the Project. The receptor can adapt to additional transportation activity and maritime safety risks with outside assistance or mitigation.
	High: The receptor is poorly suited to accommodate the type of activity proposed by the Project, and cannot fully adapt to increased transportation activity and maritime safety risks, even with outside assistance or mitigation.

Table 8.4-8 summarizes the sensitivity ratings assigned for the various types of receptors that could potentially experience marine use and transportation impacts from planned activities of the Project.

Table 8.4-8: Sensitivity Ratings for Receptors of Potential Impacts on Marine Use and Transportation

Receptor	Definition and Rationale for Inclusion	Sensitivity Rating	Rationale for Rating
Commercial cargo vessels	Includes all international and regional commercial cargo vessel activity making calls at Georgetown Harbour, as well as traversing the northern coast of South America. Project activities will occur in areas potentially used by commercial shipping organizations, and will require use of Georgetown Harbour.	Low	Georgetown Harbour is an active commercial port, where vessel traffic—such as Project-related traffic—is expected. Commercial vessels in international waters are expected to be able to safely navigate around other vessels (whether in transit or stationary).
Commercial fishing vessels	Includes commercial fishing vessels (i.e., those who sell their product to local or international markets) that operate in Guyana coastal and offshore waters. These vessels may interact with Project vessels, or may currently conduct fishing operations in or near defined marine safety exclusion zones in the PDA.	Medium	Commercial fishing vessels will lose access to some fishing areas that are currently available to them, and will have to avoid Project-related vessel traffic where none currently exists; however, operators are likely to be aware of Project activities, or at least of commercial shipping activity in the vicinity of Georgetown, and can alter their fishing grounds to avoid defined marine safety exclusion zones in the PDA.

Receptor	Definition and Rationale for Inclusion	Sensitivity Rating	Rationale for Rating
Subsistence fishing vessels	Includes individuals whose fishing activity is primarily or solely to feed themselves, their family, or their community, and not for commercial sales. These individuals generally operate near shore.	Medium	Subsistence fishing vessels are usually small, with limited ability to identify or avoid Project vessels. They will not lose access to their existing fishing areas or encounter Project-related vessel traffic outside of existing areas of high vessel traffic, but may not receive notice of Project-related activities.

8.4.3.4. Impact Significance—Marine Use and Transportation

Based on the magnitude of impact and receptor sensitivity ratings, the significance of potential Project impacts on marine use and transportation ranges from **Negligible** to **Minor**.

8.4.4. Management Measures—Marine Use and Transportation

To reduce the magnitude of potential marine use and transportation impacts, EEPGL will issue Notices to Mariners through MARAD for their communication with the public, and will provide information to the Department of Fisheries for their distribution to stakeholders (including associations, co-ops, and fisherfolk) within the fishing industry in country, regarding movements of major marine vessels (including the FPSO, drill ship, and installation vessels)—to aid them in avoiding areas with concentrations of Project vessels and/or where marine safety exclusion zones are active. Additionally, EEPGL will augment its ongoing stakeholder engagement process (and will work with government authorities through their existing notification/control processes) to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners, and communicate planned Project activities to those individuals/entities to aid them in avoiding major Project vessels where possible, as further mitigation.

In the case of commercial fishing vessel loss of access to the marine safety exclusion zones, these measures are expected to be effective means of communicating with the relatively limited number of potentially impacted stakeholders. Accordingly, the magnitude of impact to these receptors, considering implementation of mitigation measures, will be reduced to **Negligible**. While these mitigations are expected to reduce the magnitude of navigation-related impacts on commercial and subsistence fishing vessels, it may not be possible to communicate with all potentially impacted stakeholders. Therefore, the significance of potential impacts on both receptors is conservatively maintained at **Minor**.

Table 8.4-9 summarizes the embedded controls, mitigation measures, and monitoring measures relevant to this receptor.

Table 8.4-9: List of Embedded Controls, Mitigation Measures, and Monitoring Measures

Embedded Controls
Maintain marine safety exclusion zones to be issued through MARAD with a 500-meter (approximately 1,640-foot) radius around drill ships and major installation vessels, to prevent unauthorized vessels from entering areas with an elevated risk of collision.
Maintain marine safety exclusion zones to be issued through MARAD with a 2-nautical-mile (3.7-kilometer) (approximately 12,150-foot) radius around FPSO during offloading operations, to prevent unauthorized vessels from entering areas with an elevated risk of collision.
Equip Project vessels with radar systems and communication mechanisms to communicate with third-party mariners.
Observe standard international and local navigation procedures in and around the Georgetown Harbour and Demerara River, as well as best ship-keeping and navigation practices while at sea.
Mitigation Measures
Notices to Mariners are issued through MARAD for their communication with the public, and information is provided to the Department of Fisheries for their distribution to stakeholders (including associations, co-ops, and fisherfolk) within the fishing industry in country, regarding movements of major marine vessels (including the FPSO, drill ship, and installation vessels)—to aid them in avoiding areas with concentrations of Project vessels and/or where marine safety exclusion zones are active.
Augment ongoing stakeholder engagement process (along with relevant authorities) to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners and, where possible, communicate with them regarding major vessel movements and marine safety exclusion zones.
Monitoring Measures
Record instances of marine vessels entering marine safety exclusion zones.
Monitor frequency of engagement with stakeholders, including fisherfolk, coastal communities, vulnerable groups, and indigenous populations.

Table 8.4-10 summarizes the assessment of potential pre-mitigation and residual impacts on marine use and transportation. The significance of impacts was rated based on the impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the marine use and transportation-specific methodology described in Sections 8.4.3.2 and 8.4.3.3.

Table 8.4-10: Summary of Potential Pre-Mitigation and Residual Impacts—Marine Use and Transportation

Stage	Resource/Receptor Impact	Embedded Controls	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Drilling Installation, Commissioning, and Start-up Decommissioning	Commercial cargo vessels—port and channel operations	Marine safety exclusion zones around FPSO, drill ship, and major installation vessels.	Small	Low	Negligible	• Notices to Mariners and other communication materials regarding major vessel movements and marine safety exclusion zones • Augment ongoing stakeholder engagement process to communicate Project activities to the fishing community, including individuals who might not ordinarily receive Notices to Mariners	Negligible
	Commercial fishing vessels—exclusion from PDA		Small	Medium	Minor		Negligible
	Commercial cargo vessels—offshore navigation		Small	Low	Negligible		Negligible
	Commercial fishing vessels—offshore navigation		Small	Medium	Minor		Minor
	Subsistence fishing vessels—nearshore navigation		Small	Medium	Minor		Minor
Production Operations	Commercial cargo vessels—port and channel operations	Marine safety exclusion zones around FPSO and major installation vessels.	Small	Low	Negligible		Negligible
	Commercial fishing vessels—exclusion from PDA		Small	Medium	Minor		Negligible
	Commercial cargo vessels—offshore navigation		Small	Low	Negligible		Negligible
	Commercial fishing vessels—offshore navigation		Small	Medium	Minor		Minor
	Subsistence fishing vessels—nearshore navigation		Small	Medium	Minor		Minor

8.5. SOCIAL INFRASTRUCTURE AND SERVICES

8.5.1. Administrative Framework—Social Infrastructure and Services

Table 8.5-1 summarizes the legislation, policies, or treaty commitments that are specifically relevant to the assessment of potential impacts on social infrastructure and services.

Table 8.5-1: Legislation, Policies, or Treaty Commitments—Social Infrastructure and Services

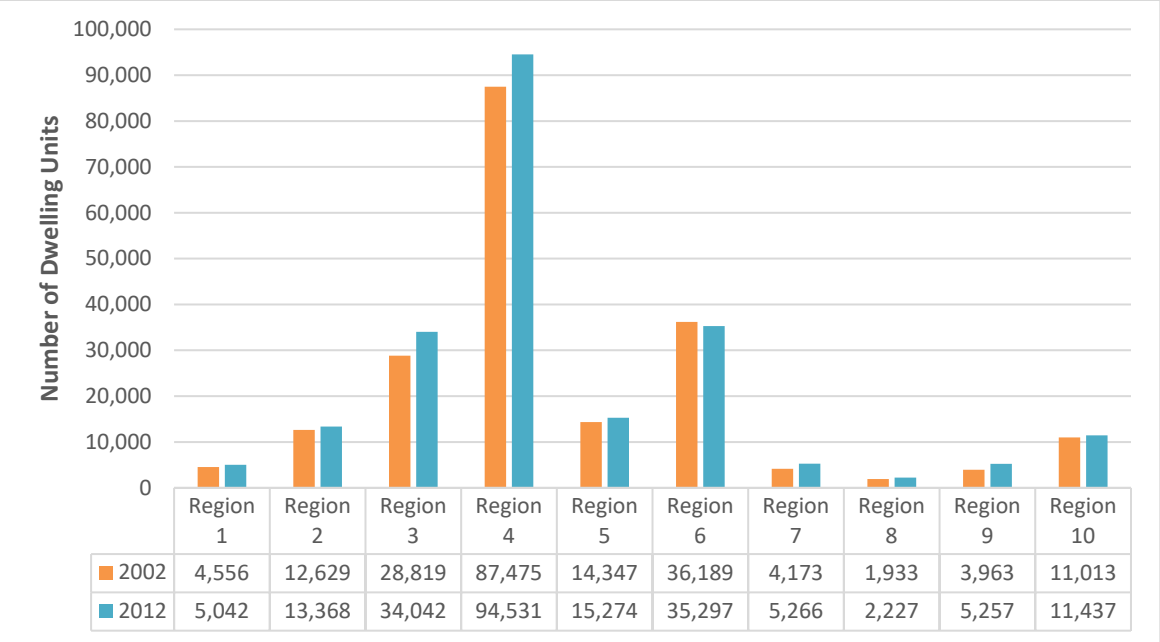
Title	Objective	Relevance to the Project
Legislation		
Sea Defence Act (1953, 1988, 1992) Cap. 64:03.	Aims to make better provision for the maintenance and construction of sea defenses in Guyana, which includes manmade structures as well as natural defenses.	Covers the protection of mangroves, which serve as a natural sea defense mechanism; there are fines and penalties for the unpermitted destruction of mangroves. Relevant to the Project in the unlikely event of an oil spill reaching the shore and causing mangrove damage.
Ministry of Health Act (2005)	Outlines the responsibilities and functions of the Ministry of Public Health, including responsibilities in relation to health care facilities.	Generally applies to health care services supplied to Project workers.

8.5.2. Existing Conditions—Social Infrastructure and Services

This section describes existing conditions for social infrastructure and services in the Project AOI. The section addresses the following social infrastructure services: housing, utilities and other social services (excluding medical services, which are addressed in Section 8.3, Community Health and Wellbeing), and ground and air transportation. Sub-categories include Housing, Lodging, Water and Sanitation, Power, Telecommunications Infrastructure, Educational Facilities, Security Facilities, Ground Transport Infrastructure, and Air Transport Infrastructure.

8.5.2.1. Housing

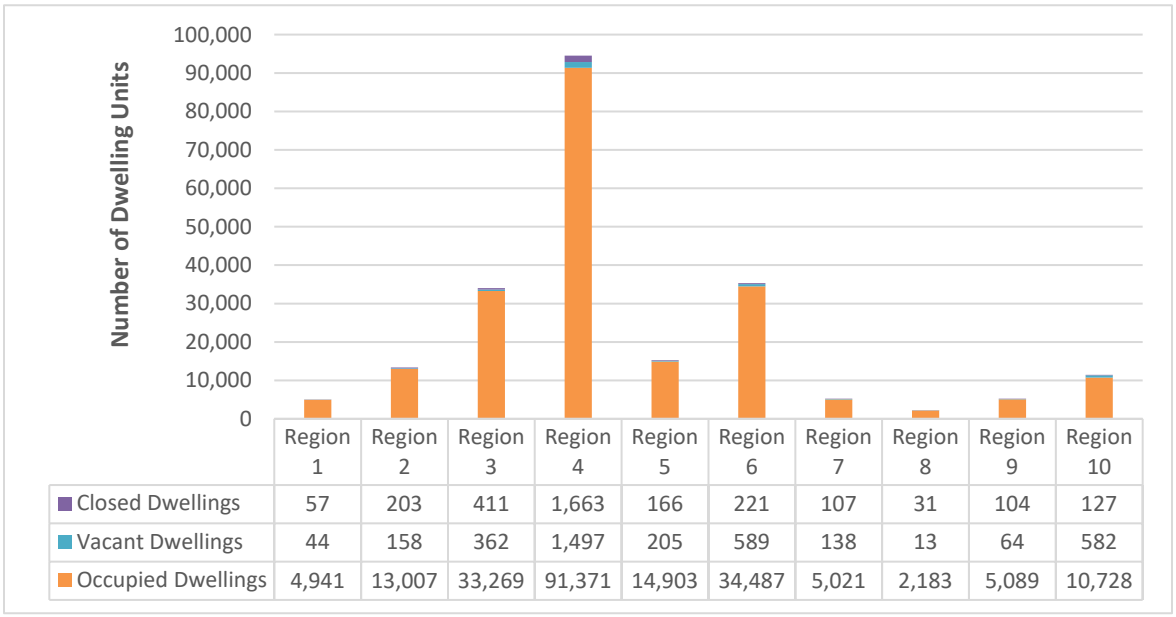
According to the 2012 census results (BSG 2012), a total of 221,741 dwelling units were recorded in the country, which was an increase of 8.1 percent in comparison to the 2002 census results. Regions 3, 4, and 6 contain the largest proportion of the population and, as expected, recorded the highest number of dwelling units in both the 2002 and 2012 census years. Figure 8.5-1 shows the number of dwelling units by region. According to the 2012 data, 214,999 of the total 221,741 dwelling units were occupied, suggesting that only 3 percent were either vacant or closed dwelling units, compared to 8.8 percent in the 2002 census. Occupancy rates were high for all ten administrative regions according to the 2012 census (see Figure 8.5-2).



	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
2002	4,556	12,629	28,819	87,475	14,347	36,189	4,173	1,933	3,963	11,013
2012	5,042	13,368	34,042	94,531	15,274	35,297	5,266	2,227	5,257	11,437

Source: BSG 2012

Figure 8.5-1: Regional Distribution of Dwelling Units: 2002 and 2012



	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
Closed Dwellings	57	203	411	1,663	166	221	107	31	104	127
Vacant Dwellings	44	158	362	1,497	205	589	138	13	64	582
Occupied Dwellings	4,941	13,007	33,269	91,371	14,903	34,487	5,021	2,183	5,089	10,728

Source: BSG 2012

Figure 8.5-2: Number of Occupied, Closed and Vacant Dwelling Units: 2012

Detached houses are the most common type of housing in all regions, and a majority of homes in the coastal area are owned by their occupants, as indicated by the 2012 census. However, the census data indicate that Regions 3 and 4 have a higher proportion of rented and squatted homes, which is consistent with data obtained during the late 2017 and early 2018 ecosystem services fieldwork (ERM/EMC 2018). In addition, according to an IDB study on the housing

sector of six Caribbean countries, Guyana has a housing deficit of 20,000 units for the low-income category (IDB 2016b).

Georgetown has a population density of 104.4 people per square kilometer (km^2) as compared with the six coastal regions (which have a combined population density of 9.6 people per km^2) and the four hinterland regions (which have a combined population density of less than one person per km^2) (IDB 2016b). According to several realtors based in Region 4, the residential market in Georgetown is mainly comprised of nuclear families with children; up to 70 percent of the residences are rentals. The realtors indicated that households with multi-generational families and extended families are not common in Georgetown. The main constraints to home ownership identified were low incomes, high mortgage interest rates, and low availability of preferred locations. In the more affluent areas of Georgetown, where gated communities and secure homes are available, single-family home values currently range from $50 million to $70 million GYD ($250,000 to $350,000 USD) (EMC Personal Communications 7, 8, 9).

In 2019, local relators stated that the residential market in Georgetown is small, and that since oil was discovered in 2015, there have been increases in both demand and prices of purchased and rental homes and apartments in Georgetown. Shortages are reported in the rental markets at price points between $50,000 and $85,000 GYD per month ($250 to $425 USD per month) and in the home-buying markets at price points ranging from $15 million to $40 million GYD ($75,000 to $200,000 USD) in Georgetown. Increased investments in executive housing, apartment complexes, and office spaces that may be linked to the oil and gas sector have been observed by realtors (EMC Personal Communications 7, 8, 9).

Informal housing settlements increased in the 1980s and 1990s due to housing supply constraints, causing many people to occupy vacant parcels (IDB 2016a). The former Ministry of Communities (now the Ministry of Local Government) has worked in recent years to regularize some informal settlements, particularly in the Georgetown area, by providing services such as paved streets, drainage, septic tanks, and water supply. If informal settlement sites are not suitable for regularization to permanent neighborhoods, they are moved to other locations (ERM Personal Communication 8; IDB 2016a, 2016b). There are currently 216 informal settlements in the country, of which 154 have been brought under the regularization program (IDB 2016a).

Data from the Bureau of Statistics' MICS (Bureau of Statistics et al. 2015) indicate that the majority of homes in Guyana have finished floors (81.2 percent), roofs (97 percent), and walls (93.2 percent). However, housing stock in some regions is aging and in need of upgrade (IDB 2016a). According to the 2002 census, more than 30 percent of the housing stock in Regions 3, 4, 5, and 6 were built before 1970.

8.5.2.2. Lodging

In Guyana, lodgings include hotels, guesthouses, and resorts—the latter of which are located mainly in hinterland areas. Accommodation capacities are relatively small and occupancy rates tend to be low. In addition, there are several small-scale lodgings that are not graded or certified (IDB 2015). According to data from the Guyana Tourism Authority, accommodation capacity in

Guyana has been steadily increasing, with room capacity increasing by more than 90 percent in 2017 (3,338 rooms) as compared with 2006 (1,716 rooms). The majority of visitors in Guyana stay in private homes and hotels. However, the data from the Guyana Tourism Authority suggest the number of visitors staying in private homes declined from 2015 to 2017, while there were increases in visitors staying in hotels, guesthouses, and apartments. The number of visitors to Guyana staying in resorts also declined. This could be related to the number of reported business travelers, which has increased from 15,543 in 2012 to 24,855 in 2017 (GTA 2018). The tourism sector in Guyana, including the hotel and lodging segment, was severely affected by the COVID-19 pandemic (Ragobeer 2020). However, the decline in tourist room occupancy of established hotels during the pandemic was offset by the oil and gas sector (including EEPGL and service companies), which booked entire venues for their workers for the duration of 2020 and 2021.[26]

A list of the most commonly frequented hotels in Region 4 and their capacities as of 2019 is presented in Table 8.5-2.

Table 8.5-2: Room Numbers at Principal Hotels in Region 4, 2021

Name of Lodging	Number of Rooms
Alpha Guest House	35
Guyana Marriott Hotel	197
Princess Hotel	191
Pegasus Hotel Guyana	134
Tower Suites	74
Regency Suites	40
Grand Coastal Hotel	43
Sleepin International Hotel	56
Sleepin International Hotel and Casino	152
Brandsville Hotel	34
Brittany's Hotel	39
Cara Lodge	34
K & VC International Ltd.	40
King's Plaza Hotel	33
Ocean View Hotel	44
Park Vue Hotel	32
Tropical View International Hotel	32

Source: Guyana Tourism Authority 2021a

Most hotels in Georgetown offer similar basic amenities, including Wi-Fi, restaurants, bars, fitness centers, swimming pools, ensuite bathrooms, free parking, laundry services, and television. In addition, some also provide business centers and conference facilities. However, there is significant variability in the daily rates for the hotels between international and

[26] Lodging data presented in this section includes data from 2019 and selected updates for 2020. Due to the significant effects of the COVID-19 pandemic on the tourism and hospitality sector (including hotels) in 2020, occupancy and other data from 2019 is expected to be more representative of future conditions during planned Project construction and operation.

non-international brands; the former offer additional services and have higher ratings and prices. The majority of accommodation capacity is centralized in Region 4, particularly in Georgetown, where several major internationally branded hotels are located.

Over the period April to May 2019, the Consultants requested feedback from 14 hotels in Region 4 on the facilities they offer and general demand forecasting, including any influence from the increased activity in the oil and gas sector, and received responses via questionnaire from seven hotels: Pegasus Hotel Guyana, Regency Suites, Grand Coastal Hotel, Brandsville Hotel, Cara Lodge, El Dorado Inn, and Kanuku Suites. Based on the responses, the Pegasus Hotel Guyana and Grand Coastal Hotel reported average capacity rates of more than 70 percent. Disaggregated data on the origins of their guests are not available, but they indicated that a majority are foreigners.

The room rates at the Pegasus Hotel Guyana were the highest among the hotels that provided feedback. At the time of the survey, daily room rates varied from $39,000 to $50,000 GYD ($195 to $250 USD) at the Pegasus Hotel Guyana and $14,000 to $27,800 GYD ($70 to $139 USD) at the Grand Coastal Hotel.

The Pegasus Hotel Guyana is expanding, with the construction of a 200-suite hotel, conference centers, and executive office space that was expected to be operational by early 2021. However, construction was delayed by the availability of construction materials due to the effects of the COVID-19 pandemic. The Grand Coastal Hotel indicated that there are no current plans for expansion. The Grand Coastal Hotel is currently closed to the public as it is presently fully booked by EEPGL to provide holdover lodging for its offshore workers (EMC Personal Communications 15, 16).

The remaining five responding hotels reported average capacity rates (pre-COVID-19) that fluctuate from 40 to 70 percent based on the season. In particular, the Brandsville Hotel indicated that capacity rates vary based on peak seasons for business travel. Seasons and availability of rooms also influence the rates of rooms. The majority of the guests at these hotels are foreigners. Cara Lodge, Brandsville Hotel, and El Dorado Inn all reported changes in vacancy rates and origin of guests over the last 2 to 3 years that they suggested could be linked to the oil and gas sector. Regency Suites observed lower vacancy rates, but this was attributed to the facilities they provide. Of the hotels surveyed, only Regency Suites has disaggregated data on the origins of the guests, with approximately 25 percent of guests being Guyanese, 30 percent from CARICOM countries, and the remaining 45 percent from other foreign countries. At the time of the survey, Regency Suites reported the lowest daily room rates at $11,400 GYD ($57 USD) and also offered options for permanent housing. In addition, Cara Lodge, Kanuku Suites, Brandsville Hotel, and Regency Suites indicated that works expansion and upgrades were planned or underway as of 2019 (EMC Personal Communications 10, 11, 12, 13, 14).

The Marriott Hotel is popular with both Guyanese visiting Georgetown and travelers affiliated with the oil and gas sector. To address accommodation needs associated with the COVID-19 pandemic, workers from EEPGL and service companies are currently occupying much of the

hotel. According to TripAdvisor.com, the average price range for a standard room at the Marriott is between $48,000 and $100,000 GYD ($240 and $500 USD) (TripAdvisor 2021).

In 2020, the Government of Guyana through the Guyana Office for Foreign and Local Investment published a call for the Expression of Interests for the construction of hotels in Guyana. In November 2020, agreements were signed for the development of four hotels in Region 4. Among the intended hotel projects are a $18 billion GYD ($90 million USD) Hilton Garden Inn at Houston/Mc Doom (East Bank Demerara), a Delta Hotels Marriott near the Cheddi Jagan International Airport, an H-Towers luxury hotel in New Providence (on the East Bank), and a SureStay Plus Hotel by Best Western (in the city center) (Papannah 2020).

8.5.2.3. Water and Sanitation

Official data on water usage is difficult to obtain, but the United Nations estimates that irrigation use takes up a significant portion, followed by municipalities (FAO 2021).

Potable Water

Most potable water is obtained from the deeper aquifers that underlie Georgetown and the coastal plain. GWI, a commercial public enterprise, distributes water in five service areas along the coast, and has a separate program to serve communities in the Hinterlands. GWI derives 90 percent of its water from groundwater sources and the remaining 10 percent from surface water sources (GWI Undated_a). Groundwater is extracted from 250 wells and is processed in 28 water treatment plants (GWI 2020). The former Ministry of Communities[27] and GWI have established several new wells in the Hinterland regions, including in communities in Regions 1 and 9. New wells were also established in Region 4. In addition, GWI is working to increase access to treated water in Region 1 and intends to establish several water treatment plants in Georgetown (Guyana Chronicle 2018).

In rural areas not served by GWI, domestic water is obtained from a mix of groundwater, surface water, and rainwater sources. Rainwater is often used for potable household use, while river water is typically used for cleaning and other non-potable uses. The Food and Agriculture Organization estimated that in 2012, 98 percent of the population had access to improved water sources (FAO 2015)

Businesses that use large quantities of water, such as beverage bottling and food processing plants, generally have their own wells to meet their needs (FAO 2015).

Agricultural-Use Water

Declared Drainage and Irrigation Areas (areas with fully developed drainage and irrigation systems) are found in Regions 2, 3, 4, 5, and 6. In these regions, irrigation is conducted via gravity flow from surface water resources trapped by shallow earthen dams known as “conservancies.” These are located in the upper stream catchment areas and store water at elevations higher than those of the surrounding fields. In other schemes, water is pumped from rivers into the irrigation canals. In addition, there are several engineered conservancies that

[27] Now Ministry of Local Government

supply water to agricultural lands in coastal regions. The Tapakuma Conservancy serves Region 2 and has been designed to provide irrigation to about 12,000 hectares (29,650 acres). During times of water shortage, this conservancy is supplemented by pumping from the Pomeroon River (FAO 2015). The Boeraserie Conservancy supplies Region 3, the East Demerara Water Conservancy supplies Region 4 and the Mahaica-Mahaicony-Abary / Agricultural Development Authority supplies water to Region 5.

The National Drainage and Irrigation Authority of the Ministry of Agriculture has responsibility for the maintenance and delivery of the irrigation water supply throughout the country. This authority works with the conservancies' boards, water users associations, farmer groups, and local government bodies to maintain irrigation and drainage systems in an operational and efficient manner.

Sanitation

In addition to potable water, GWI provides sanitation services in Georgetown. Wastewater collection is provided through sewerage systems in central Georgetown, and in the Tucville-Stevedore housing schemes, servicing approximately 60,000 residents plus a non-residential population of approximately 200,000 persons. The GWI has plans to construct two wastewater treatment facilities for each of these sewerage systems (i.e., central Georgetown and Tucville-Stevedore; GWI Undated_b).

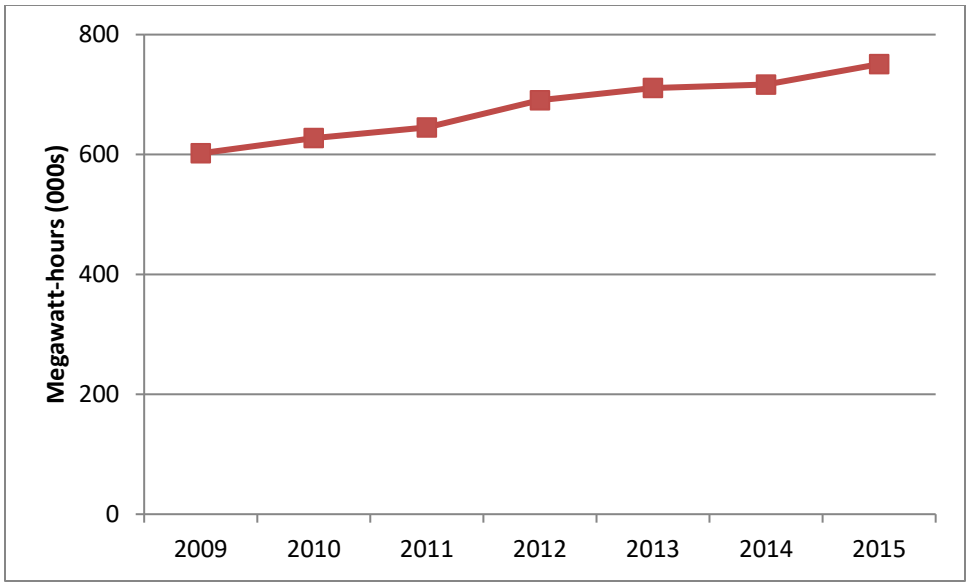
8.5.2.4. Power

Most of the electricity in the coastal plain of Guyana is generated, transmitted, and distributed by the state-owned utility Guyana Power & Light. However, due to poor reliability, many users also have their own diesel generators. Coastal areas that are not serviced by Guyana Power & Light are the Region 2 area west of Charity, and Region 1. Most areas of the Hinterlands do not have electric supply, and the government has implemented a number of Hinterland energy development projects in recent years, including solar system installations and feasibility studies for hydropower and wind projects (GPL 2011). According to the Guyana Energy Agency, a number of renewable energy projects are planned, including photovoltaic plants at Legaun and Mahdia. A 400-kilowatt solar farm was commissioned in 2021 at Mabaruma in Region 1 (Ragobeer 2021).

The PSC has noted that the high cost of electricity in Guyana is a major challenge for businesses. During the late 2017 and early 2018 ecosystem services field work, this was raised as an issue by representatives of agricultural processing associations as well as local community leaders (ERM Personal Communications 1, 5, 10; ERM/EMC 2018).

According to the PSC, hydroelectricity development should be a major priority for the country. The plan for the 165-megawatt Amaila Falls hydroelectric plant was cancelled in 2015 due to delays and the potential for cost overruns (ERM Personal Communication 10).

Figure 8.5-3 shows the total electricity generation output in Guyana in thousands of megawatt-hours for the period 2009 through 2015.



Source: Ministry of Finance 2015

Figure 8.5-3: Electricity Generation in Guyana, 2009–2015

Although Guyana has significant potential for hydroelectric, solar, and biomass-fueled electricity generation, in 2020, 92 percent of its installed generation capacity was thermal, relying on expensive imported heavy oil and diesel fuels and making average electricity prices among the highest in Latin America and the Caribbean (U.S. Department of Energy 2020). Of the remaining installed capacity, 7 percent was biomass-based, using bagasse (sugarcane fibers remaining after cane juice is extracted) as fuel to self-generate power at Guyana Sugar Corporation's sugarcane factories, and solar was 1 percent. There are plans to enhance the generation capacity of the factories such that excess power is available and can be exported to the national electrical grid, and the government is working toward a strategy to diversify Guyana's energy mix with renewable energy technologies focused on wind, solar, and small hydroelectric (GEA 2016; ClimateScope 2017).

During 2017 and 2018, the government implemented a Green Public Sector Programme, which saw the installation of a combined capacity of 3.02 megawatts of solar photovoltaic systems on the rooftops of 175 public or government buildings, and 65 solar-powered light-emitting diode streetlights (GEA undated). Solar farms are planned for other areas in the Hinterlands including Port Kaituma and Matthew's Ridge in Region 1 (GEA undated). In January 2019, a $1.6 billion GYD ($8 million USD) low-cost loan was approved by the Abu Dhabi Fund for Development and the International Renewable Energy Agency for the installation of a 5.2-megawatt grid-connected solar photovoltaic system in Guyana (DPI 2019b). In June 2019, Norway approved the release of $16 billion GYD ($80 million USD) to fund 30-megawatt solar farms with storage in Hinterland communities (DPI 2019a). Further, in 2019, private developer Guyana Wind Farm Inc. indicated intentions to establish the Hope Beach Wind Farm at Hope, East Coast Demerara in Region 4. In June 2021, the company submitted its EIA to the EPA (OilNOW 2021). The wind farm will comprise four turbines, which are intended to supply 13 megawatts of power to the national grid (Ramroop 2019).

8.5.2.5. Telecommunications Infrastructure

The majority of households in the coastal regions have access to mobile phone service. There were 646,000 mobile connections in Guyana in January 2020 with a mobile connection rate of 82 percent of the population (Datareportal.com 2020). The lack of 4G network access, a previous major barrier to increased business investment in Guyana, was addressed in 2016 with the installation of the country's first 4G network. In addition, the government has signaled its intention to prioritize the economic liberalization of Guyana's telecommunications market to encourage greater investment in the sector (Guyana Chronicle 2019).

Internet service in Guyana consists of two major communications companies and a number of smaller companies providing broadband and satellite services. The services are more available on the coastland with dwindling availability in the hinterland. The internet penetration rate for the 2020 was 55 percent with 430,000 users (Datareportal.com 2020). Internet users in Guyana increased by 10,000 between 2019 and 2020. The Government of Guyana has embarked on a number of programs to address the internet inequity in the country; most notable of these is the national eGovernment Programme, which developed a Digital Governance Roadmap for Guyana (e-Governance Academy 2018).

8.5.2.6. Educational Facilities

Table 8.5-3 shows the number of nursery, primary, secondary, and post-secondary schools in each of the coastal regions. The majority of post-secondary institutions (technical schools, colleges, and universities) are found in Georgetown.

Table 8.5-3: Number of Educational Facilities in Guyana's Coastal Regions

	Nursery	Primary	Secondary	Technical/ Vocational	Special Schools	College/ University
Region 1	17	53	3	0	0	0
Region 2	36	42	8	1	0	0
Region 3	45	58	13	1	0	0
Region 4	58	55	48	10	2	15
Region 5	31	30	7	3	0	0
Region 6	57	56	18	2	0	2

Source: EMC Personal Communication 1, 2, 3; Ministry of Education undated

The distribution of schools in the coastal regions compared with other areas reflects population trends along the coast. Schools are found all along the coast of Regions 3, 4, 5, and 6, which are the most populated regions. In Region 2, schools are found along the coast until the coastal road ends, and there are fewer schools in Region 2 areas west of Charity and in Region 1.

At the tertiary level, the country has one national public higher education institution, the University of Guyana. The university has two campuses in the country, the Turkeyen Campus in Region 4 and the Tain Campus in Region 6, both of which offer undergraduate and graduate programs. In addition, through its Institute of Distance and Continuing Education, the university offers extramural classes and online programs in Regions 2, 4, 6 and 10. The University of Guyana has an enrollment of approximately 10,000 students (University of Guyana 2021).

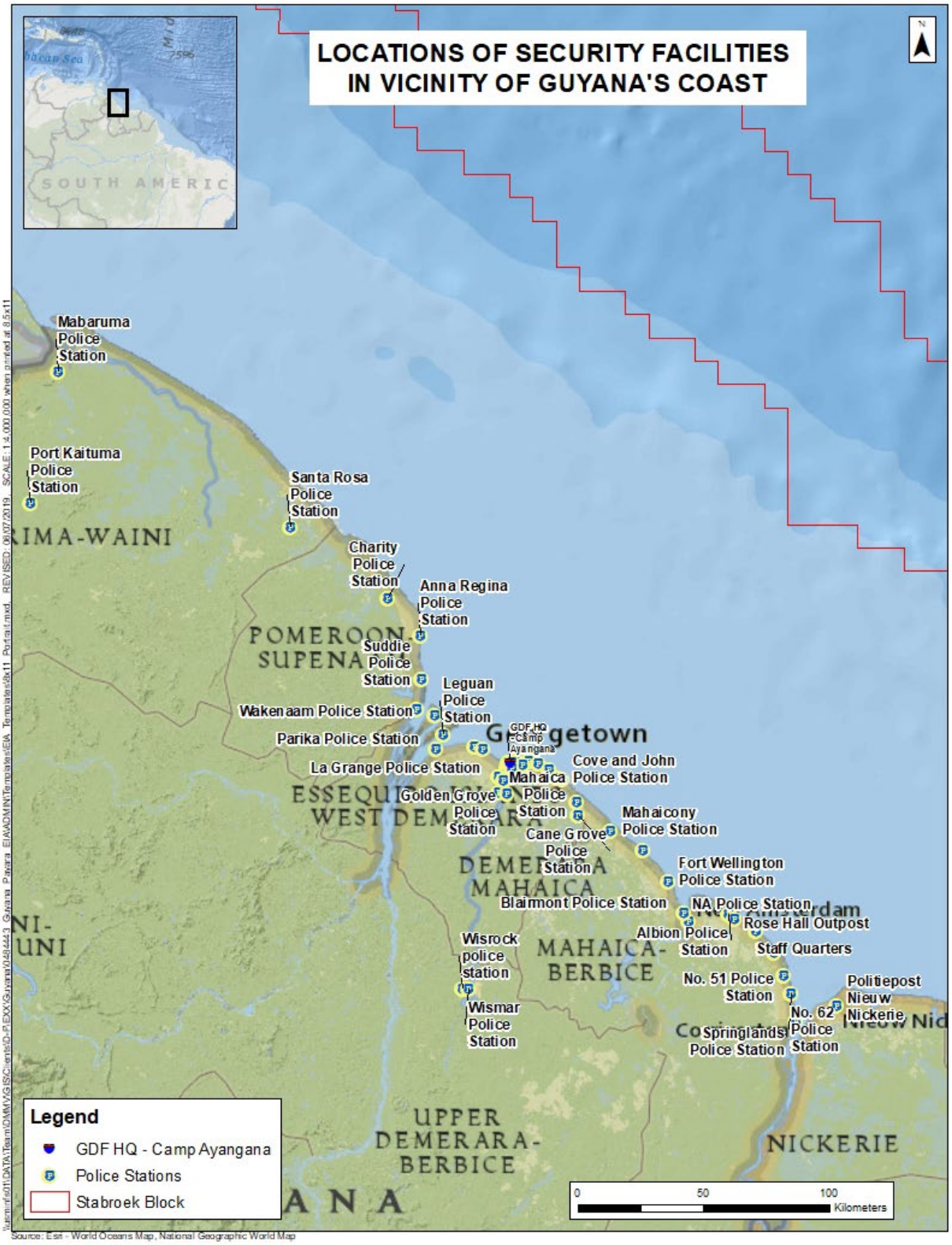
8.5.2.7. Security Facilities

The Guyana Defense Force is the military service of Guyana and has land, sea (Coast Guard), and air (Air Corps) units responsible for defending the territorial integrity of Guyana. In terms of internal security, the Guyana Police Service operates as a semiautonomous agency under the Ministry of Home Affairs. The Guyana Police Service has seven geographic policing divisions, each with its own headquarters, stations, and outposts, as summarized in Table 8.5-4.

Table 8.5-4: Policing Divisions in Guyana

Division	Geographic Area	Headquarters Location	Number of Stations	Number of Outposts
A	City of Georgetown and the East Bank of the Demerara River, including the Cheddi Jagan International Airport, Timehri, 40 kilometers (25 miles) from Georgetown	Brickdam, Georgetown	9	7
B	County of Berbice but excluding Kwakwani	Coburg Street, New Amsterdam	12	5
C	County of Demerara, east of the Demerara River but excluding A Division	Cove & John, East Coast Demerara	8	4
D	County of Demerara, west of the Demerara River and a portion of the East Bank of the Essequibo River	Leonora, West Coast Demerara	6	1
E & F	Upper Demerara including the area surrounding the bauxite holdings of Linden, Ituni, and Kwakwani, and the interior	Rabbit Walk, Eve Leary, Georgetown	30	6
G	Essequibo Coast including the islands of the Essequibo and Pomeroon Rivers	Anna Regina, Essequibo Coast	6	0

Figure 8.5-4 shows the locations of 35 (approximately 50 percent) of the total reported police stations in Guyana listed in the table above (locational data were not available for the interior outpost locations).



Note: Map does not represent a depiction of the maritime boundary lines of Guyana.

Figure 8.5-4: Locations of Security Facilities in Immediate Vicinity of Guyana's Coast

8.5.2.8. Ground Transportation Infrastructure

Road Network

Guyana has an approximately 3,990-kilometer (approximately 2,480-mile) road network serving a country of 214,920 km^2 (82,981 square miles [mi^2]), for a ratio of 0.018 kilometer of road per km^2 (IDB 2019). There are six main national paved roads that each has two lanes, except for four-lane segments along the East Bank and East Coast Demerara roads. The road network is dependent on a system of bridges and culverts that provide crossings over a dense system of canals, drains, and sluices throughout the coastal lowlands.

Georgetown has a compact, grid-based street network. Road conditions vary widely and can be poor in some locations. The port area is linked to central Georgetown via the East Bank Demerara Road. Most intersections are not signal-controlled; where signals do exist, they can be frequently out of service. Pedestrian overpasses were recently installed at several areas along the East Bank Demerara Road to improve pedestrian safety and assist in reducing traffic congestion.

Existing Traffic Volumes and Congestion

Traffic congestion is a chronic problem in and around Georgetown. Many different types of vehicles, including cars, large commercial vehicles, mini-buses, horse-drawn carts, bicycles, mopeds, scooters, and motorcycles, all share the same travel lanes. Traffic congestion occurs frequently, in particular just before and just after school hours.

A number of factors contribute to poor and dangerous land transportation conditions, including driving behavior, a combination of aggressive and timid vehicle operators, ongoing road repairs/construction, lack of streetlights, lack of enforcement of traffic laws, and narrow roads and streets. Speeding, aggressive driving, and driving under the influence of alcohol contribute to traffic accidents in Georgetown. Driving at night poses additional concerns due to poor street lighting and road conditions, as well as livestock and pedestrians congregating near the roadside or, in the case of livestock, occasionally standing in the traffic lanes (OSAC 2020).

The Ministry of Public Works is working with the IDB to develop a Sustainable Urban Transport Plan for Georgetown. This will focus more on management of current traffic than on addition of significant new infrastructure (e.g., separation of slower-moving traffic from vehicular traffic in designated lanes; ERM Personal Communication 9).

In March 2018, the Caribbean Transportation Consultancy Services Company Limited (CARITRANS) completed a survey of existing traffic conditions along the East Bank Demerara Road, in the general vicinity of an existing shorebase facility that is planned to be used by the Project. The study involved five turning movement counts and two average daily traffic counts along the East Bank Demerara Road.

Table 8.5-5 provides a summary of traffic volume information collected from the 2018 survey, specifically focused on morning and afternoon peak hour (maximum hour of activity) traffic volumes at each survey location. Morning peak hours generally occur between 7:00 and

8:00 a.m., while afternoon peak hours vary considerably between 1:15 and 7:45 p.m. Morning peak-hour traffic volume is generally higher than during the afternoon peak hour.

Table 8.5-5: Peak Hour Traffic, East Bank Demerara Road (Surveyed March 2018)

Location	Morning Peak Hour		Afternoon Peak Hour	
	Time	Traffic Volume	Time	Traffic Volume
Houston Split (Intersection)	7:30–8:30	5,324	4:30–5:30	4,484
Houston Village [a]	7:00–8:00	3,705	2:00–3:00	3,107
Eccles Intersection	7:00–8:00	3,627	4:15–5:15	3,328
Demerara Harbour Bridge	6:30–7:30	2,752	1:15–2:15	2,709
Nandy Park Intersection	7:00–8:00	2,678	1:45–2:45	2,309
Massey Intersection	6:45–7:45	2,850	6:45–7:45	2,259
Providence Village [a]	9:00–10:00	2,087	6:00–7:00	2,179

Source: CARITRANS 2018

[a] Traffic counts at Houston Village and Providence Village measured only straight-line traffic (counts at all other locations measured all intersection turning movements). Data for Houston Village and Providence Village reflect the average weekday traffic recorded between 15 March and 20 March 2018.

In 2019, CARITRANS completed a survey of existing traffic conditions along additional road segments within the greater Georgetown area. The study involved turning movement counts at 42 additional intersections around six key locations within the Georgetown area that were expected to potentially be used by EEPGL-related vehicles (either related to the Project or to other non-Project EEPGL-related activities):

- Marriott
- EEPGL Office Complex/Ogle
- Contractor Commercial Port A
- Contractor Inland Storage Yard
- Contractor Shorebase B
- Ramada Intersection

Figure 8.5-5 shows these key locations and the 47 study intersections (including the locations surveyed in 2018). Results for the additional 2019 study intersections are presented below, grouped by key location.

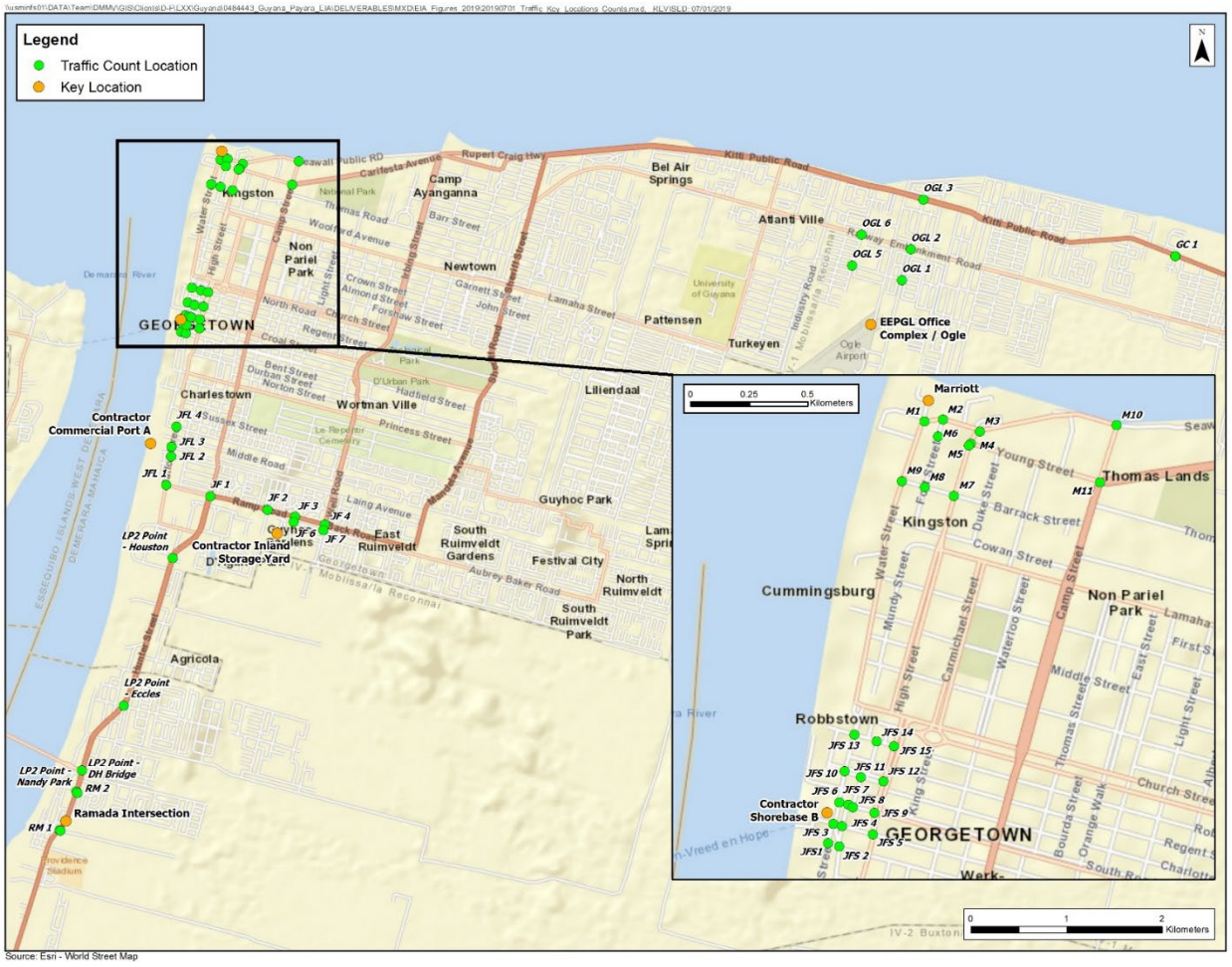


Figure 8.5-5: Key Locations and Traffic Count Locations for 2018 and 2019 Traffic Studies

Table 8.5-6 provides a summary of traffic volume information collected from the 2019 survey, specifically focused on morning and afternoon peak hour (maximum hour of activity) traffic volumes at each survey location. Morning peak-hour traffic volume is generally higher than during the afternoon peak hour. The full report containing these data is included as Appendix T, Traffic Impact Assessment.[28]

Table 8.5-6: Peak Hour Traffic, 2019 Georgetown Area Traffic Count Locations

Traffic Count Location	Morning Peak Hour		Afternoon Peak Hour	
	Time	Traffic Volume	Time	Traffic Volume
JFL-1	7:15 a.m.–8:15 a.m.	960	4:45 p.m.–5:45 p.m.	1,253
JFL-2	8:45 a.m.–9:45 a.m.	293	2:15 p.m.–3:15 p.m.	291
JFL-3	10:15 a.m.–11:15 a.m.	852	4:00 p.m.–5:00 p.m.	757
JFL-4	9:30 a.m.–10:30 a.m.	1,380	3:30 p.m.–4:30 p.m.	1,318

[28] Due to the significant effects of the COVID-19 pandemic on the economic, business, and social environment in 2020, traffic data from 2019 is expected to be more representative of future conditions during planned Project construction and operation.

Traffic Count Location	Morning Peak Hour		Afternoon Peak Hour	
	Time	Traffic Volume	Time	Traffic Volume
JF-1	8:45 a.m.–9:45 a.m.	1,220	5:00 p.m.–6:00 p.m.	1,221
JF-2	7:15 a.m.–8:15 a.m.	946	5:00 p.m.–6:00 p.m.	841
JF-3	9:45 a.m.–10:45 a.m.	990	3:00 p.m.–4:00 p.m.	877
JF-4	7:00 a.m.–8:00 a.m.	1,220	5:00 p.m.–6:00 p.m.	1,189
JF-6	7:00 a.m.–8:00 a.m.	161	4:45 p.m.–5:45 p.m.	128
JF-7	10:30 a.m.–11:30 a.m.	370	1:15 p.m.–2:15 p.m.	322
JFS-1	7:00 a.m.–8:00 a.m.	182	5:00 p.m.–6:00 p.m.	145
JFS-2	7:15 a.m.–8:15 a.m.	1,041	4:15 p.m.–5:15 p.m.	878
JFS-3	7:00 a.m.–8:00 a.m.	315	4:15 p.m.–5:15 p.m.	368
JFS-4	7:45 a.m.–8:45 a.m.	580	4:00 p.m.–5:00 p.m.	609
JFS-5	10:45 a.m.–11:45 a.m.	859	3:30 p.m.–4:30 p.m.	879
JFS-6	7:30 a.m.–8:30 a.m.	347	1:00 p.m.–2:00 p.m.	213
JFS-7	6:30 a.m.–7:30 a.m.	519	3:45 p.m.–4:45 p.m.	368
JFS-8	7:30 a.m.–8:30 a.m.	320	5:00 p.m.–6:00 p.m.	239
JFS-9	8:00 a.m.–9:00 a.m.	898	3:30 p.m.–4:30 p.m.	618
JFS-10	7:00 a.m.–8:00 a.m.	591	3:45 p.m.–4:45 p.m.	411
JFS-11	8:45 a.m.–9:45 a.m.	266	4:45 p.m.–5:45 p.m.	209
JFS-12	10:30 a.m.–11:30 a.m.	322	5:00 p.m.–6:00 p.m.	264
JFS-13	7:30 a.m.–8:30 a.m.	774	4:30 p.m.–5:30 p.m.	581
JFS-14	9:00 a.m.–10:00 a.m.	189	4:00 p.m.–5:00 p.m.	160
JFS-15	10:30 a.m.–11:30 a.m.	478	5:00 p.m.–6:00 p.m.	396
M-1	7:45 a.m.–8:45 a.m.	680	4:00 p.m.–5:00 p.m.	121
M-2	7:45 a.m.–8:45 a.m.	516	1:00 p.m.–2:00 p.m.	108
M-3	7:45 a.m.–8:45 a.m.	871	4:15 p.m.–5:15 p.m.	108
M-4	7:45 a.m.–8:45 a.m.	1,017	4:15 p.m.–5:15 p.m.	125
M-5	7:45 a.m.–8:45 a.m.	823	2:45 p.m.–3:45 p.m.	107
M-6	8:00 a.m.–9:00 a.m.	112	2:45 p.m.–3:45 p.m.	59
M-7	7:45 a.m.–8:45 a.m.	1,261	4:15 p.m.–5:15 p.m.	378
M-8	8:15 a.m.–9:15 a.m.	462	4:15 p.m.–5:15 p.m.	207
M-9	7:45 a.m.–8:45 a.m.	635	4:15 p.m.–5:15 p.m.	248
M-10	7:30 a.m.–8:30 a.m.	828	4:30 p.m.–5:30 p.m.	250
M-11	7:30 a.m.–8:30 a.m.	1,580	4:15 p.m.–5:15 p.m.	475
GC-1	8:30 a.m.–9:30 a.m.	1,057	4:45 p.m.–5:45 p.m.	1,086
OGL-1	8:30 a.m.–9:30 a.m.	631	1:30 p.m.–2:30 p.m.	518
OGL-2	10:00 a.m.–11:00 a.m.	1,605	2:45 p.m.–3:45 p.m.	1,497
OGL-3	8:45 a.m.–9:45 a.m.	1,309	1:30 p.m.–2:30 p.m.	1,433
OGL-5	7:45 a.m.–8:45 a.m.	716	4:30 p.m.–5:30 p.m.	560
OGL-6	9:30 a.m.–10:30 a.m.	1,662	2:30 p.m.–3:30 p.m.	1,458

Source: Appendix T, Traffic Impact Assessment

In addition to surveying existing traffic volumes, CARITRANS used the traffic analysis model VISSIM to complete an assessment of the existing Level of Service (LOS) for each of the 2018 and 2019 study intersections, for each direction of travel through the intersections and for the various movements (through, right turn, left turn, U-turn) completed at each intersection. LOS is a standard numerical measure of the delay expected to be experienced at an intersection, compared to expected norms; it is expressed as a letter grade between A (least delay) and F (most delay, gridlock). The results of LOS modeling for the 2018 and 2019 study intersections are presented below.

Level of Service Modeling for 2018 Intersections

For the 2018 study, Level of Service (LOS) modeling for existing conditions was completed for morning peak hours, afternoon peak hours, and afternoon peak hours when the Demerara Harbour Bridge was closed. The detailed modeled LOS ratings for these scenarios are summarized in the Traffic Impact Assessment Report (CARITRANS 2018) provided as an appendix to the Liza Phase 2 Development EIA. Table 8.5-7 summarizes the findings of the LOS modeling for existing conditions at the 2018 study intersections.

Table 8.5-7: Results of Level of Service Modeling for Existing Conditions; 2018 East Bank Demerara Road Study Intersections

Location	Direction	Movement	Level of Service		
			Morning	Afternoon	Afternoon, Bridge Closed
Massey Intersection	Northbound	Through	A	A	A
		Right	A	A	A
		U-Turn	A	A	A
	Southbound	Left	A	A	A
		Through	A	A	A
	Westbound	Right	A	A	A
		U-Turn	A	A	A
		Left	A	A	A
Demerara Harbour Bridge	Demerara Harbour Bridge (Exit)	Right	F	C	NA
		Left	D	A	NA
	Northbound	U-Turn	C	NA	A
		Left	A	F	A
		Through	D	A	A
	Southbound	Through	E	A	A
		Right	F	F	A
		U-Turn	F	A	A
Houston Split (Intersection)	Southbound	Through	A	A	A
	Northbound	Right	E	A	A
		Left	F	A	A
Nandy Park Intersection	Northbound	Through	B	A	A

Location	Direction	Movement	Level of Service		
			Morning	Afternoon	Afternoon, Bridge Closed
		Right	D	B	A
	Southbound	U-Turn	C	A	A
		Through	A	A	A
		Left	A	A	A
	Westbound	Right	A	B	A
		Left	F	A	A
Eccles Intersection	Southbound	Through	D	B	C
		Left	E	D	C
	Northbound	Right	F	D	C
		Through	D	A	C
	Westbound	Left	F	E	B
		Right	F	E	A

Source: CARITRANS 2018

NA = LOS data not available

The East Bank Demerara Road is particularly susceptible to congestion due to backups at the Demerara Harbour Bridge, the only road crossing of the Demerara River (Figure 8.5-6). Daily retraction of the bridge for a period of about 1 hour causes severe traffic congestion at both ends of the bridge. As shown in Table 8.5-7, when the bridge is open (i.e., when vehicles cannot cross), several movements at the intersection of the Demerara Harbour Bridge with the East Bank Demerara Road operate at an LOS rating of “F”, indicating significant delays and near-gridlock conditions. When the bridge is closed, the entire East Bank Demerara Road system operates at an LOS rating of “C” or better, typically considered acceptable conditions for urban traffic.

Figure 8.5-6: Demerara Harbour Bridge

The Demerara Harbour Bridge in Georgetown has been in operation for approximately 40 years and is no longer able to efficiently service either present or estimated future traffic demands. The Government of Guyana has elected replacement of the heavily used bridge as a means of relieving congestion of both road- and river-based vessel traffic induced by the opening and closing of the retractor spans that allow large vessels to pass. In 2013, a pre-feasibility study identified three alternative locations for the new bridge: Houston, Peters Hall (the existing location), and New Hope. In August 2021, the Ministry of Public Infrastructure issued a project summary evaluating replacement of the bridge, calling for the replacement bridge to span the Demerara River from Nandy Park to La Grange, slightly upstream of the existing bridge (Figure 10.4-1), and for the existing bridge to be closed and demolished once the new bridge is in operation. The replacement structure will be a fixed four-lane bridge with a vertical clearance over the channel of approximately 50 meters (164 feet) above the maximum tide level. The proposed design connects to the main road network at the West Bank Public Road and the Mandela to Eccles Road (MoPW 2021). The EPA has exempted the new bridge project from

having to do an EIA, requiring instead an Environmental and Social Assessment and Management Plan (Kaieteur News 2021).

Level of Service Modeling for 2019 Intersections

For the 2019 study intersections, LOS modeling for existing conditions was completed for morning peak hours and afternoon peak hours. Tables 8.5-8a through 8.5-8e summarizes the findings of the LOS modeling for the 2019 study intersections. The full report containing these data is included as Appendix T, Traffic Impact Assessment.

Table 8.5-8a: Results of Level of Service Modeling for Existing Conditions; 2019 Georgetown Area Study Intersections—Marriott Key Location

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
M1	Southbound	Right	A	A
		Left	A	A
		Through	A	A
	Eastbound	Through	A	A
		Right	A	A
	Westbound	Right	A	A
		Through	A	A
		U-Turn	A	A
		Left	A	A
	Northbound	Through	A	A
		Right	A	A
		U-Turn	A	A
M2	Eastbound	Through	A	A
	Westbound	Through	A	A
	Northbound	Left	C	A
		Right	C	A
M3	Eastbound	Through	F	C
		Right	F	D
	Westbound	Through	C	A
		Left	C	B
	Northbound	Left	A	A
		Right	A	A
		U-Turn	E	D
M4	Southbound	Through	C	C
		Left	C	B
	Northbound	Through	A	A
		Left	A	A
	Westbound	Right	B	A
		Left	B	A

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
M5	Southbound	Right	A	A
		Through	A	A
	Northbound	Through	A	A
		Right	A	A
M6	Northbound	Through	C	A
	Westbound	Right	A	A
M7	Northbound	U-Turn	A	A
		Right	A	A
		Left	A	A
		Through	A	A
	Westbound	Left	A	A
		Through	A	A
		Right	A	A
	Eastbound	Right	A	A
		Through	A	A
		Left	A	A
	Southbound	Through	A	A
		Left	A	A
		Right	A	A
		U-Turn	A	A
M8	Northbound	Through	A	A
		Right	A	A
		Left	A	A
	Westbound	Left	A	A
		Right	A	A
		U-Turn	A	A
		Through	A	A
	Eastbound	Right	A	A
		Left	A	A
		Through	A	A
M9	Northbound	Through	A	A
		Right	A	A
	Southbound	Through	A	A
		Left	A	A
	Westbound	Left	A	A
		Right	A	A
M10	Westbound	Through	A	A
		Left	A	A
	Eastbound	Through	A	A
		Right	A	A
	Northbound	Right	A	A

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
		Left	A	A
M11	Northbound	Right	D	D
		Through	D	D
		Left	A	A
	Westbound	Left	D	D
		Right	E	E
		Through	E	E
	Southbound	Through	D	F
		Left	D	E
		Right	D	F
	Eastbound	Right	C	C
		Through	C	C
		Left	A	A

Table 8.5-8b: Results of Level of Service Modeling for Existing Conditions; 2019 Georgetown Area Study Intersections—EEPGL Office Complex/Ogle Key Location

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
OGL 6	Eastbound	Left	C	C
		Through	C	C
		Right	D	D
	Westbound	Right	C	C
		Through	C	B
		Left	B	B
	Northbound	Through	F	D
		Left	F	C
		Right	F	C
OGL 5	Northbound	Left	A	A
		Right	A	A
		Through	A	A
	Eastbound	Right	A	A
		Through	A	A
		Left	A	A
	Westbound	Left	A	A
		Through	A	A
		Right	A	A
	Southbound	Through	A	A
		Right	A	A
		Left	A	A

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
OGL 1	Northbound	Right	A	A
		Left	A	A
	Westbound	Left	A	A
		Through	A	A
		Right	A	A
	Southbound	Left	A	A
		Right	A	A
	Eastbound	Through	A	A
		Left	A	A
OGL 2	Westbound	Right	B	A
		Through	A	A
		Left	A	A
	Southbound	Left	E	D
		Right	F	E
		Through	E	E
	Eastbound	Through	A	A
		Left	A	A
		Right	A	A
	Northbound	Right	D	D
		Through	D	C
		Left	C	B
OGL 3	Southbound	Right	F	F
		Through	F	F
		Left	F	F
	Eastbound	Left	D	E
		Right	E	E
		Through	E	E
	Northbound	Through	D	D
		Left	B	B
	Westbound	Right	C	C
		Through	C	C
		Left	B	B

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
GC 1	Southbound	Through	A	A
		Left	A	A
		Right	A	A
	Northbound	Through	A	A
		Right	A	A
		Left	A	A
	Westbound	Right	A	A
		Left	A	A
		U-Turn	A	A
		Through	A	A
	Eastbound	Left	A	A
		Right	A	A
		Through	A	A
		U-Turn	A	A

Table 8.5-8c: Results of Level of Service Modeling for Existing Conditions; 2019 Georgetown Area Study Intersections—Contractor Commercial Port A and Contractor Inland Storage Yard Key Locations

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
JFL4	Southbound	Left	B	B
		Through	B	B
	Northbound	Through	A	A
JFL3	Westbound	Left	A	A
	Northbound	Through	A	A
	Southbound	Left	A	A
		Through	A	A
JFL2	Westbound	Right	A	A
		Left	A	A
	Southbound	Through	A	A
JFL1	Northbound	Right	A	A
		Left	A	A
	Southbound	Through	A	A
		Right	A	A
	Westbound	Left	A	D
		Through	C	E
	Eastbound	Right	A	A
		Through	A	A

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
JF1	Southbound	Through	F	F
		Right	F	F
		Left	F	F
	Northbound	Through	D	D
		Left	A	A
		Right	D	D
	Eastbound	Left	A	A
		Right	D	D
		Through	D	D
	Westbound	Right	C	C
		Left	C	B
		Through	C	C
JF2	Northbound	Right	A	A
	Eastbound	Right	A	A
		Left	A	A
		Through	A	A
	Southbound	Right	A	A
		Left	A	A
	Westbound	Left	A	A
		Through	A	A
		Right	A	A
JF3	Northbound	Right	A	A
		Left	A	A
	Westbound	Left	A	A
		Through	A	A
	Eastbound	Right	A	A
		Through	A	A
JF6	Northbound	Through	A	A
		Right	A	A
	Southbound	Left	A	A
	Westbound	Left	A	A
		Right	A	A
JF4	Westbound	Right	A	A
		Through	A	A
		Left	A	A
	Eastbound	Left	A	A
		Through	A	A
		Right	A	A
	Northbound	Through	A	A
		Right	A	A
		Left	A	A

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
JF7	Northbound	Left	A	A
		Through	A	A
	Westbound	Left	A	A
		Through	A	A
		Right	A	A
	Eastbound	Right	A	A
		Through	A	A
		Left	A	A
	Southbound	Through	A	A
		Left	A	A
		Right	A	A

Table 8.5-8d: Results of Level of Service Modeling for Existing Conditions; 2019 Georgetown Area Study Intersections—Contractor Shorebase B Key Location

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
JFS5	Northbound	Right	F	F
		Left	F	F
		Through	F	F
	Westbound	Left	F	F
		U-Turn	F	F
		Through	F	F
		Right	F	F
	Eastbound	Right	F	F
		Through	F	F
		Left	F	F
	Southbound	Through	E	E
		Left	D	D
		Right	D	E
JFS9	Southbound	Left	F	F
		Through	F	F
		Right	F	F
	Westbound	U-Turn	F	F
		Right	F	F
		Through	F	F
		Left	F	F
	Northbound	Right	F	F
		Through	F	F
JFS12	Eastbound	Left	A	A
	Northbound	Through	A	A

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
JFS11	Southbound	Right	A	A
		Left	A	A
	Eastbound	Through	A	A
JFS10	Northbound	Left	A	A
		Right	A	A
		Through	A	A
	Southbound	Left	A	A
JFS13	Southbound	Right	A	A
		Through	A	A
		Left	A	A
	Eastbound	Left	A	A
		Through	A	A
	Northbound	Through	A	A
		Left	A	A
		Right	A	A
JFS14	Eastbound	Left	A	A
		Through	A	A
JFS4	Eastbound	Right	A	C
		Through	C	E
	Westbound	Left	A	A
	Southbound	Right	E	F
		Through	D	F
		Left	F	F
JFS3	Eastbound	Through	A	D
		Left	A	C
	Northbound	Right	B	D
		Through	A	A
	Westbound	Right	A	A
JFS2	Northbound	Right	A	A
		Left	A	A
JFS11	Eastbound	Left	A	A
		Through	A	A
	Westbound	Left	A	A
JFS7	Westbound	Left	E	F
		Through	F	F
	Southbound	Right	D	C
JFS6	Northbound	Through	A	A
	Westbound	Right	A	A
JFS1	Westbound	Left	A	A
		Through	A	A
		Right	A	A

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
JFS15	Eastbound	Left	A	A
	Northbound	Through	A	A
		Right	A	A

Table 8.5-8e: Results of Level of Service Modeling for Existing Conditions; 2019 Georgetown Area Study Intersections—Ramada Intersection Key Location

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
Site	Direction	Movement	LOS	LOS
LP2 Point Massy	Northbound	Through	A	A
		Right	A	A
		U-Turn	A	A
	Southbound	Left	A	A
		Through	A	A
	Westbound	Right	A	A
		U-Turn	A	A
		Left	A	A
LP2 Point DH Bridge	Eastbound	Right	E	C
		Left	B	A
	Northbound	Through (Ln3)	A	B
		Left	A	B
		Through	A	B
	Southbound	Through	D	F
		Right	E	A
		U-Turn	E	A
LP2 Point Houston	Southbound	Through	A	A
	Northbound	Through (Ln3)	F	A
		Through	E	A
		Left	F	A
LP2 Point Nandy Park	Northbound	Through	A	A
		Right	A	A
	Southbound	U-Turn	A	A
		Through	A	A
		Left	A	A
	Westbound	Right	A	B
		Left	A	B

Site	Direction	Movement	Level of Service	
			Morning	Afternoon
LP2 Point Eccles	Southbound	Through	B	E
		Left	D	F
	Northbound	Through (Ln3)	C	C
		Through	C	F
		Right	D	E
	Westbound	Left	E	
		Right	E	

Some of the existing road networks observed were characterized by less-than-ideal conditions, in particular the signalized intersections. It was observed that at all of the signalized intersections included in the study, police officers were present during peak periods to regulate traffic and alleviate congestion at the intersections. The high delays and LOS F ratings for these intersections indicate a need to optimize signal timings to allow for more efficient operations at the intersection and network levels. The following was therefore noted:

- The Contractor Shorebase B location is in an area where there is already a high level of activity that directly affects traffic flows, resulting in substantial delays on the surrounding streets and spillover congestion into a number of major intersections.
- The Ramada Intersection location features high levels of northbound traffic into Georgetown in the morning and the reverse in the afternoon, resulting in significant delay and congestion.
- The EEPGL Office Complex/Ogle location shows high volumes of east-west traffic as vehicles go to and from Georgetown. The signalized intersection is observed to not efficiently handle the elevated volumes.

8.5.2.9. Air Transportation Infrastructure

Air transportation in Guyana supports a variety of sectors including agriculture, tourism, and the extractive sectors. Air transportation infrastructure is therefore critical to sustain and enhance economic competitiveness. Guyana ranks 131 out of 211 countries on the Air Connectivity Index (World Bank 2011), and 49 out of 141 economies for the quality of its air transportation infrastructure (World Economic Forum 2015). In 2017, at the World Aviation Forum, Guyana was awarded for moving from 44.24 percent to 64.66 percent effective implementation of the Standards and Recommended Practices of the International Civil Aviation Organization (Stabroek News 2017). Compliance with the standards advances Guyana's efforts to be classified as a Federal Aviation Administration International Strategy Assessment Programme Category 1 country and facilitates direct flights to the United States.

Guyana's air transportation infrastructure comprises two international airports: the Cheddi Jagan International Airport (CJIA) and the Eugene F. Correira International Airport (ECIA; also commonly referred to as Ogle Airport). In addition, nearly 100 aerodromes serve smaller towns and villages, principally in the Hinterland regions (IDB 2016c). The CJIA and ECIA provide direct international flights to English- and Dutch-speaking Caribbean, South America, Central

America, and North America countries. A 2016 IDB tender document for development of a National Civil Aviation Master Plan for Guyana notes that approximately 478,000 passengers and 6,148,000 kilograms of cargo moved through the CJIA and approximately 43,700 passengers moved through the ECIA (IDB 2016c). In 2017, the most recent year for which data are available, 664,000 international passengers used Guyana's airports, representing a 6 percent annual growth rate from the prior year (GCAA 2018). Considering visitor (i.e., non-resident) arrivals, numbers have been steadily increasing over the past decade from 156,910 in 2011 to 247,330 in 2017 and 314,727 in 2019. With the impact of the COVID-19 pandemic, visitor numbers dropped sharply to 86,503 in 2020 and approximately 62,000 as of June 2021 (Guyana Tourism Authority 2021b).

The CJIA is located at Timehri, 40 kilometers (25 miles) south of Georgetown. The CJIA is managed by a Chief Executive Officer who reports, through a Board of Directors, to the Minister of Public Works (GoG 2006). The airport's existing terminal building has been operational since the 1970s, runways are short, and parking facilities congested. Over the period 2000–2012, passenger traffic at the CJIA increased 42 percent, from 384,000 to 544,000 (MoPW 2018). Given these circumstances, in 2013 a project for the expansion and modernization of the CJIA commenced and is expected to be completed by the end of 2021. The expansion project includes extension of the North and South runways, construction of new departure and arrival terminals, passenger boarding bridges, new aircraft parking bays, a diesel generator room, and a fire pump station. Upgraded sections of the airport are currently in use, but expansion and renovation works are ongoing. In June 2021, a $200 million GYD ($1 million USD) Instrument Landing System was completed.

The ECIA is located approximately 6 kilometers (3.7 miles) from Georgetown. In late 2001, the government leased the management and operation of the aerodrome to a local consortium of airline operators, Ogle Airport Inc. The lease is for a minimum period of 25 years with extension periods of 25 years on request of the lessee. The objective of the lease is to ensure compliance with International Civil Aviation Organization standards and to serve as a back up to the CJIA in the event of an emergency, disaster, accident, or other unserviceable situation (GoG 2006). The ECIA has developed into the principal domestic air hub, providing commercial and cargo transport services, primarily between Georgetown and the Hinterland regions. In 2009, ECIA received International Port of Entry certification and now serves direct flights to three CARICOM states: Barbados, Suriname, and Trinidad. ECIA is capable of handling small aircraft, such as business jets, and the ATR-72 operated by Leeward Islands Air Transport (EMC Personal Communication 17). In 2018, ECIA's domestic operations/flight landings totaled 16,500 and international operations/flight landings totaled 2,100 (EMC Personal Communication 17). ECIA is also the base of EEPGL's local air transportation contractor, Bristow. By comparison, the extended CJIA runway measures 3,360 meters (approximately 2 miles), making it a Code 4E runway able to accommodate a Boeing 747-400 (Ahamad 2021).

Only a small number of the nearly 100 aerodromes principally serving smaller towns and villages in the Hinterland region have asphalt, concrete, or bitumen surfaces, including Bath, Bimichi, Ebini, Hampton Court, Holiptu, Kaieteur, Kamarang, Kimbia, Lethem, Linden,

Mabaruma, Mahdia, and Maards. Along the coast, there are other airstrips at Skeldon, Albion, Rose Hall, Von Betta, Bath, Maards, Hampton Court, Kwebanna, and Mabaruma.

8.5.3. Impact Assessment—Social Infrastructure and Services

This section assesses potential Project impacts on social infrastructure and services in the Project AOI. The planned Project activities that have the potential to impact social infrastructure and services are Project worker presence (with the potential to impact availability or cost of lodging and/or of housing and utilities) and Project-related ground and air transportation activities (with the potential to increase traffic congestion). Potential impacts to lodging, housing and utilities, and ground and air transportation are assessed separately in this section.

Potential impacts related to decreased availability of emergency medical and health services as a result of Project use of these services are assessed in Section 8.3.3, Impact Assessment—Community Health and Wellbeing. Potential impacts related to vehicle accidents involving non-Project individuals are assessed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

In mid-2019, the Consultants conducted a housing and accommodation demand survey to better facilitate an assessment of the potential impacts of EEPGL's operations on the local lodging and housing markets in and around Georgetown. EEPGL and their eight primary onshore and offshore support companies were asked to provide existing and forecasted data on housing purchases, housing rentals, and lodging demand. It should be noted that these data represent demand by staff and workers for all of EEPGL-related activities across Guyana, so the data are not specific to the Project. The survey data have been compiled and presented in Section 8.5.3.1, Lodging, and Section 8.5.3.2, Housing and Utilities.

8.5.3.1. Lodging

Relevant Project Activities and Potential Impacts

Although the Project will have limited onshore planned activities, the presence of Project workers has the potential to increase demand for lodging in the Georgetown area. Table 8.5-9 summarizes the Project stages and activities that could result in potential impacts on lodging, as well as the receptors that could potentially experience these impacts.

Table 8.5-9: Summary of Relevant Project Activities and Key Potential Impacts—Lodging

Stage	Receptor(s)	Project Activity	Key Potential Impacts
All Project Stages	Leisure and business travelers to Guyana, specifically Georgetown and vicinity	Project-related worker presence in Georgetown area	Increased demand or use of lodging, leading to reduced availability and/or increased cost

Magnitude of Impact—Lodging

The assessment of the Project's magnitude of impacts on lodging is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on lodging is defined according to the definitions provided in Table 8.5-10.

Table 8.5-10: Definitions for Intensity Ratings for Potential Impacts on Lodging

Criterion	Definition
Intensity	Negligible: There is no discernible change in demand for lodging.
	Low: Limited increases in demand for lodging are perceptible, causing slight changes in the availability, quality, and/or cost of these resources and services.
	Medium: Increases in demand for lodging are evident and lead to frequent and widespread shortfalls in availability or quality of lodging, or measurable increases in costs.
	High: Increases in demand for lodging are sufficient to cause conditions of chronic shortage and inflated costs.

EEPGL applies a vetting process for lodging options against EEPGL's health, safety, and security criteria, and several hotels in Georgetown are considered "approved" for use by Project-related personnel (although EEPGL approval status does not apply to EEPGL's primary support companies). As of mid-2019, the demand for hotel rooms in Georgetown by EEPGL and its primary support companies averaged a total of 600 rooms per month, for an average stay of 2.5 nights per booking. The hotels (some of which are "EEPGL-approved") most commonly rented by EEPGL staff and many of its primary support companies include Guyana Marriott Hotel, Grand Coastal Hotel, Pegasus Hotel Guyana, Ramada Georgetown Princess Hotel, Kings Hotel and Residences, Cara Lodge, and Herdmanston Lodge. The average stay for offshore workers, which make up a majority of the demand (more than 400 rooms per month), is one night per month. The remainder of the lodging demand is for company management and staff visiting Georgetown for a short duration, usually no more than five nights per stay, and typically on the order of one trip per month. During 2020 and 2021, EEPGL used several hotels (including the Marriott, Grand Coastal, and Cara Lodge) as staging areas for crew changes and isolation prior to going offshore to ensure safe operations during the COVID-19 pandemic; however, this is considered atypical.

In the improbable event that the monthly demand of 600 rooms were to occur on the same night, this would have a significant impact on the lodging market, as this demand represents more than 100 percent of the bed capacity at the aforementioned five Georgetown hotels typically used by EEPGL and its primary support companies (but only approximately 18 percent of the 3,338 current Guyana-wide hotel bed capacity). However, according to the raw data, it is more typical for the monthly demand of 600 rooms to be spread out over the course of the month, with a maximum of 200 beds in demand by EEPGL or its primary support companies at any one time. This constitutes approximately 37 percent of the 577-bed capacity of the aforementioned five Georgetown hotels typically used by EEPGL and its primary support companies. It should be noted that the survey results also indicated that two of the primary support companies that relied on hotels for their management or expatriate staff travel to Guyana were planning on moving their staff into more permanent accommodations (e.g., house

or apartment rentals, guesthouses) in the coming 3 years. Project-specific staff demand will also decrease as the Project moves from drilling and installation and into the production operations stage (see Section 8.5.3.2, Housing and Utilities).

Considering the information presented above, potential impacts on non-Project related users of lodging as a result of Project-related demand or use of lodging will be limited to the **Direct AOI**. Given the current demand on lodging is focused primarily on five hotels and not spread across all lodging options in Georgetown, and several of these hotels reported no change in occupancy rates as a result of the oil and gas sector, the intensity of the potential impacts on lodging is rated as **Low** for drilling and installation stages (when Project workforces are highest). This intensity is expected to decrease to **Negligible** during later stages of the Project considering hotel expansion projects should be complete and the number of Project-required workers seeking hotel space will decrease. Project-related demand for lodging will occur on a routine basis throughout the Project life cycle (at least 20 years), yielding a frequency designation of **Continuous** for all stages and a duration of **Long-term**. This yields a magnitude rating of **Small** for potential impacts on lodging.

Table 8.5-11: Magnitude of Impact—Lodging

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Development Drilling SURF and FPSO Installation, Commissioning, and Start-up	Leisure and business travelers to Guyana, specifically Georgetown and vicinity—Increased demand or use of lodging, leading to reduced availability and/or increased cost	Direct AOI (Georgetown and vicinity)	Low	Continuous	Long-term	Small
Production Operations Decommissioning	Leisure and business travelers to Guyana, specifically Georgetown and vicinity—Increased demand or use of lodging, leading to reduced availability and/or increased cost	Direct AOI (Georgetown and vicinity)	Negligible	Continuous	Long-term	Negligible

Sensitivity of Receptors—Lodging

The receptors that potentially could experience impacts on lodging are leisure and business travelers to Guyana, specifically those staying within Georgetown and vicinity. The receptor sensitivity ratings for lodging are defined according to the definitions provided in Table 8.5-12.

Table 8.5-12: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Lodging

Criterion	Definition
Sensitivity	Low: Existing services have excess capacity and travelers have the resources and capability to seek alternative lodging options or meet the potential increase in price.
	Medium: Existing services have minimal excess capacity and travelers have limited resources or capability to seek alternative lodging or meet the potential increase in price.
	High: Existing services have little or no excess capacity and travelers have no resources or capability to seek alternative lodging or meet the potential increase in price.

Based on the accommodations survey conducted by the Consultants, existing lodging options, especially those most frequented by EEPGL and its primary support companies, appear to have excess capacity (30 percent or more) during peak periods, and this will potentially improve in the coming years considering current ongoing hotel expansion efforts.

Leisure and business travelers typically have the ability to respond to capacity constraints when booking their travel through use of hotel-specific and other online booking platforms. For Guyana, a majority of the hotels discussed in Table 8.5-2 are included on the most popular hotel online booking platforms. This instant access to capacity, price, and comparison of hotel amenities allows travelers to either adjust travel dates or hotel preferences. Business travelers also typically have the ability to absorb increases in price as a result of capacity constraints, while leisure travelers may have less ability. However, the sensitivity of travelers to this potential impact is individual-traveler dependent and accordingly a conservative approach is taken. A **Medium** level of sensitivity to increased demand and/or price for lodging is given.

Impact Significance—Lodging

Based on the magnitude of impact and receptor sensitivity ratings, the significance of lodging for all Project stages is **Minor** for development drilling and SURF and FPSO installation, and **Negligible** for production operations and decommissioning.

8.5.3.2. Housing and Utilities

Relevant Project Activities and Potential Impacts

Although the Project will have limited onshore planned activities, the presence of Project workers and of those seeking Project-related work has the potential to increase demand for housing and utilities in the Georgetown area. Table 8.5-13 summarizes the Project stages and activities that could result in potential impacts on housing and utilities, as well as the receptors that could potentially experience these impacts.

Table 8.5-13: Summary of Relevant Project Activities and Key Potential Impacts—Housing and Utilities

Stage	Receptor(s)	Project Activity	Key Potential Impacts
All Project Stages	General population of Georgetown and vicinity	Project worker presence in Georgetown area	Increased demand or use of housing and utilities and infrastructure, leading to reduced availability and/or increased cost
		(Induced) influx of job-seekers to Georgetown area	

Magnitude of Impact—Housing and Utilities

The assessment of the Project's magnitude of impacts on housing and utilities is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on housing and utilities is defined according to the definitions provided in Table 8.5-14.

Table 8.5-14: Definitions for Intensity Ratings for Potential Impacts on Housing and Utilities

Criterion	Definition
Intensity	Negligible: There is no discernible change in demand for housing or utilities.
	Low: Limited increases in demand for housing and utilities are perceptible, causing slight changes in the availability, quality, and/or cost of these resources and services.
	Medium: Increases in demand for housing and utilities are evident and lead to frequent and widespread shortfalls in availability or quality of housing and utilities, or measurable increases in costs.
	High: Increases in demand for housing and utilities are sufficient to cause conditions of chronic shortage and inflated costs.

The Project will require up to approximately 1,140 workers during the peak drilling and installation stages combined and up to a peak of approximately 100 to 140 workers during the production operations stage. The majority of the workforce for these stages will be based offshore; for these workers, the limited time spent onshore will predominantly be in temporary accommodations such as hotels or shared guesthouses rented by their companies. Approximately 150 to 200 persons will be based onshore on a permanent basis, providing shorebase and marine logistical support as well as supporting EEPGL's other activities in Guyana (including those related to the Project and other EEPGL exploration and production activities). EEPGL will optimize the use of local content to the extent practicable, so it is likely that a significant portion of these permanent onshore jobs will be filled by individuals currently residing in the Georgetown vicinity.

Accommodation and housing data collected from EEPGL and its primary supply companies found that in 2019, these companies had 125 rentals in the Georgetown area: 49 houses and 76 apartments. This number was expected to increase in 2020 to a range of 155 to 175 rentals, and in 2021 to a range of 199 to 219 rentals. These rentals are primarily for expatriate staff living and office space, with a few of the guesthouse rentals specifically dedicated to offshore, rotational workforce (in lieu of hotels). This portion of the workforce is expected to decrease in

later stages of the Project. Based on the survey, only four to seven houses were expected to be purchased in the coming 3 years. There were no significant concerns expressed by EEPGL or its major support companies related to the number and availability of rental houses on the market. Only one of the surveyed primary companies had Guyanese staff (seven in total) who relocated to the Georgetown vicinity from other regions as a result of their work with EEPGL. There have been no indications of large-scale influx of workers from other parts of Guyana to Georgetown in search of jobs.

The number of inhabitants in shared guesthouses, apartments, or family homes is currently approximately 10 percent of the total workforce, with the potential to be approximately 20 percent by 2021. These reflect rentals only, with only one EEPGL major support company (representing less than 1 percent of the total workforce) expected to purchase several homes. This maximum estimated number (for 2021) of 219 rentals is insignificant (less than 1 percent) compared to the Georgetown population of more than 130,000.

Realtors interviewed during the housing and accommodation survey indicated that expatriates have a decided preference for residences in Georgetown and its immediate outskirts. Some realtors claim that an increase of more than 100 new residents seeking either new home purchases or long-term rentals in the Georgetown area is expected to increase demand in the rental and home buying markets and, consequently, increase prices. One realtor anticipates that the potential price impacts of an increase at this level will also have impacts in Region 3, while other realtors do not anticipate changes in rural areas or areas outside of Georgetown (EMC Personal Communications 7, 8, 9). Although stock numbers of available houses for rent in the Georgetown and vicinity markets were not available, the viewpoints of these realtors suggest there could be an impact on the housing rental market in specific locations. Considering that the Project workforce is not expected to impact for-sale or rental housing stock (e.g., there is no demand for new housing structures to be built), there will not be expected requirements for significant new utilities connections.

Furthermore, it is not anticipated that the Project's worker presence onshore at any given time will be enough to drive development of new temporary housing/hotel establishments outside of what is already currently being planned by some Georgetown hotels. Some induced population influx from other regions of Guyana may occur as job seekers move to the Georgetown area seeking direct or indirect employment from the Project, but this number to date has reportedly been insignificant. However, any future influx would be expected to be limited and short-term in nature, given EEPGL's continuous efforts to communicate the Project's limited workforce requirements to stakeholders.

Considering the information presented above, potential impacts on housing and utilities will be primarily limited to the **Direct AOI**. Given the current demand on housing and infrastructure in Georgetown is focused on the rental market and represents less than 1 percent of the Georgetown population, the intensity of the potential impacts on housing and utilities is rated as **Low** during drilling and installation stages. By the time of the production operations and decommissioning stages, many of EEPGL's primary supply companies will have completed their Project-related work and will no longer require housing rentals or purchases within Georgetown

and the vicinity; therefore, the intensity will decrease to Negligible during production operations and decommissioning. Project-related demand for housing and utilities will occur on a routine basis throughout the Project life cycle (at least 20 years), yielding a frequency designation of **Continuous** for all stages and a duration of **Long-term**.

Based on the definitions presented in Table 8.5-15, the magnitude of impact on housing and utilities is considered to be **Small** during the drilling and installation stages of the Project and **Negligible** during the production operations and decommissioning stages.

Table 8.5-15: Magnitude of Impact—Housing and Utilities

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Development Drilling SURF and FPSO Installation, Commissioning, and Start-up	General population of Georgetown and vicinity—Increased demand or use of housing and utilities and infrastructure, leading to reduced availability and/or increased cost	Direct AOI (Georgetown and vicinity)	Low	Continuous	Long-term	Small
Production Operations Decommissioning	General population of Georgetown and vicinity—Increased demand or use of housing and utilities and infrastructure, leading to reduced availability and/or increased cost	Direct AOI (Georgetown and vicinity)	Negligible	Continuous	Long-term	Negligible

Sensitivity of Receptors—Housing and Utilities

The receptors that potentially could experience impacts on housing and utilities are the current general population of the Georgetown vicinity. The receptor sensitivity ratings for housing and utilities are defined according to the definitions provided in Table 8.5-16.

Table 8.5-16: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Housing and Utilities

Criterion	Definition
Sensitivity	Low: Existing infrastructure and services have excess capacity and/or the community has the resources and capability to expand in a timely manner.
	Medium: Existing infrastructure and services have little excess capacity and the community has limited resources or capability to expand in a timely manner and thus would require assistance in upgrading or supplementing current infrastructure and service provision in the community.
	High: Existing infrastructure and services have little or no excess capacity and the community does not have the resources or capability to respond to a potential increase in population.

As the capital of Guyana, Georgetown has a relatively high concentration of social services and infrastructure; however, according to a study by the IDB, there are currently shortfalls of housing

and appropriate utilities infrastructure in Georgetown, which the government is addressing with regularization initiatives for informal communities. The existing capacity of the housing rental market by area or community within Georgetown is also unknown. Given these shortfalls, a conservative approach is taken and the population is considered to have a **Medium** level of sensitivity to increased demand for housing and utilities infrastructure.

Impact Significance—Housing and Utilities

Based on the magnitude of impact and receptor sensitivity ratings, the significance of housing and utilities impacts for the drilling and installation stages is **Minor**. During the production operations and decommissioning stages, this is reduced to a **Negligible** level of significance.

8.5.3.3. Ground and Air Transportation

Relevant Project Activities and Potential Impacts

Planned Project activities will generate additional vehicular traffic in Georgetown, as well as additional air traffic (helicopters) between ECIA (Ogle Airport) and the PDA. Table 8.5-17 summarizes the Project stages and activities that could result in potential impacts on ground or air transportation.

Table 8.5-17: Summary of Relevant Project Activities and Key Potential Impacts—Ground and Air Transportation

Stage	Receptors	Project Activity	Key Potential Impacts
All Project stages	Road users, including drivers, cyclists, and pedestrians	Onshore movement of Project materials, supplies, and personnel	Increased vehicle traffic on public roads in and around Georgetown
All Project stages	Other aircraft and users of ECIA	Helicopter flights between ECIA and PDA	Increased air traffic leading to potential impacts on ECIA capacity

Magnitude of Impact—Ground Transportation

The assessment of the Project's magnitude of impacts on ground transportation is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on ground transportation is defined according to the definitions provided in Table 8.5-18.

Table 8.5-18: Definitions for Intensity Ratings for Potential Impacts on Ground Transportation

Criterion	Definition
Intensity	Negligible: No noticeable change in traffic congestion.
	Low: Minor changes in traffic congestion at only a limited number (5–10%) of locations, and/or significant changes in traffic congestion at a very limited number (<5%) of locations.
	Medium: Minor changes in traffic congestion at a moderate number (10–20%) of locations, and/or significant changes in traffic congestion at a limited number (5–10%) of locations.
	High: Minor changes in traffic congestion at a high number (>20%) of locations and/or significant changes in traffic congestion at a moderate number (10–20%) of locations.

Intensity was assessed based on consideration of analyses performed by CARITRANS in 2019 (covering multiple road segments across Georgetown considered to be the primary segments used by EEPGL-related vehicles). To assess the intensity of Project-related impacts on ground transportation (i.e., increased traffic congestion), CARITRANS conducted additional LOS modeling for each of the same study intersections for which baseline traffic counts were established in 2018 and 2019. This LOS modeling reflected the simulated addition of anticipated future EEPGL-related vehicle movements at the study intersections to assess whether LOS ratings were anticipated to change significantly with the addition of anticipated EEPGL-related vehicle movements. Results of this analysis by CARITRANS are included in (Appendix T, Traffic Impact Assessment) and are discussed below.

The LOS modeling conducted by CARITRANS for the Project was focused on the 47 road segments across Georgetown at which traffic counts were collected in 2018 and 2019; these include those intersections anticipated to be among the road segments more heavily used by EEPGL-related vehicle movements. The study modeled two scenarios in 2026, selected to represent a time when the Yellowtail development is planned to be in production operations, with continued development well drilling occurring. The scenarios analyzed for 2026 included:

- Baseline conditions (i.e., without EEPGL-related vehicle movements) factoring in growth in 2018/2019 measured baseline conditions at a rate of 5 percent per year; and
- Baseline conditions factoring in growth in 2018/2019 measured baseline conditions at a rate of 5 percent per year, plus additional EEPGL-related vehicle movements anticipated in 2026.

Modeling was conducted for total estimated additional EEPGL-related vehicle movements in 2026, as opposed to Yellowtail-only vehicle movements, because existing data and future estimates regarding EEPGL-related vehicle movements are not readily divisible by specific Project activity. In this sense, the modeling reflects a conservatively high estimate of the vehicle movements that would be attributed to the Project alone.

To provide a basis for CARITRANS to simulate additional EEPGL-related vehicle movements in the LOS modeling, the Consultants worked with EEPGL to develop projections of EEPGL-related vehicle movements for 2026. Vehicle movement estimates were developed from the following:

- Recorded EEPGL “fleet” vehicle movements over the period of 4 February 2019 through 28 April 2019 (EEPGL tracks the movements of its fleet vehicles—which are used for transport of EEPGL staff around Georgetown—using global positioning system devices); and
- Estimates of non-personnel EEPGL-related vehicle movements (i.e., for material, supply, waste transports, etc.).

Based on review of the actual fleet vehicle movements recorded for the above-referenced period (comprising the bulk of the overall EEPGL-related vehicle movements), the Consultants identified a list of “key points” within Georgetown, defined as a recorded “start” or “finish” point of a “key segment” recorded as being traveled at least 30 times in the 84-day period of record.

These key points were then plotted on a map that includes the intersections at which CARITRANS conducted its vehicle movement counts in 2018 and 2019 (see Figure 8.5-7).

In some cases, the recorded “start” or “finish” points were not identifiable to a specific location, but rather could only be identified to within a particular street segment. In these cases, Figure 8.5-7 displays a “key street segment.”

To estimate the potential impact of these fleet-vehicle trips on the specific intersections that were the subject of the LOS modeling, the Consultants identified—for each key segment—the intersections that could potentially be passed through while traveling the key segment. This generated a conservatively high estimate of the number of times an intersection could have been crossed by an EEPGL fleet vehicle during the period of record. In total, the 84-day period of record included data for 25,123 vehicle trips. Of these, 8,682 of the trips had a “start” and “end” point that were both identifiable (in many cases the “start” and “end” trip was the same, indicating a return to the start point with an unidentifiable route during the trip). Accordingly, the estimated numbers of intersection crossings were “scaled up” by a factor of 2.9 (25,123/8,682), representing the estimated number of potential EEPGL fleet vehicle crossings of each study intersection during the period of record (i.e., February to April 2019).

To estimate the anticipated EEPGL fleet vehicle traffic for 2026, the Consultants worked with EEPGL’s transportation coordination group to develop estimates of the expected fleet growth through 2026. The February to April 2019 counts reflected a fleet size of 36 vehicles. EEPGL’s end-of-year estimate for fleet vehicle size for 2026 is 130 vehicles. Accordingly, the estimated potential number of EEPGL fleet vehicle crossings of each study intersection for 2026 were developed taking the estimated February to April 2019 crossings and increasing them by a factor of 3.6 (130/36).

For non-personnel EEPGL vehicle movements, EEPGL’s logistics team identified key segments for these types of movements and provided direct estimates of trip-counts along these key segments for 2026.

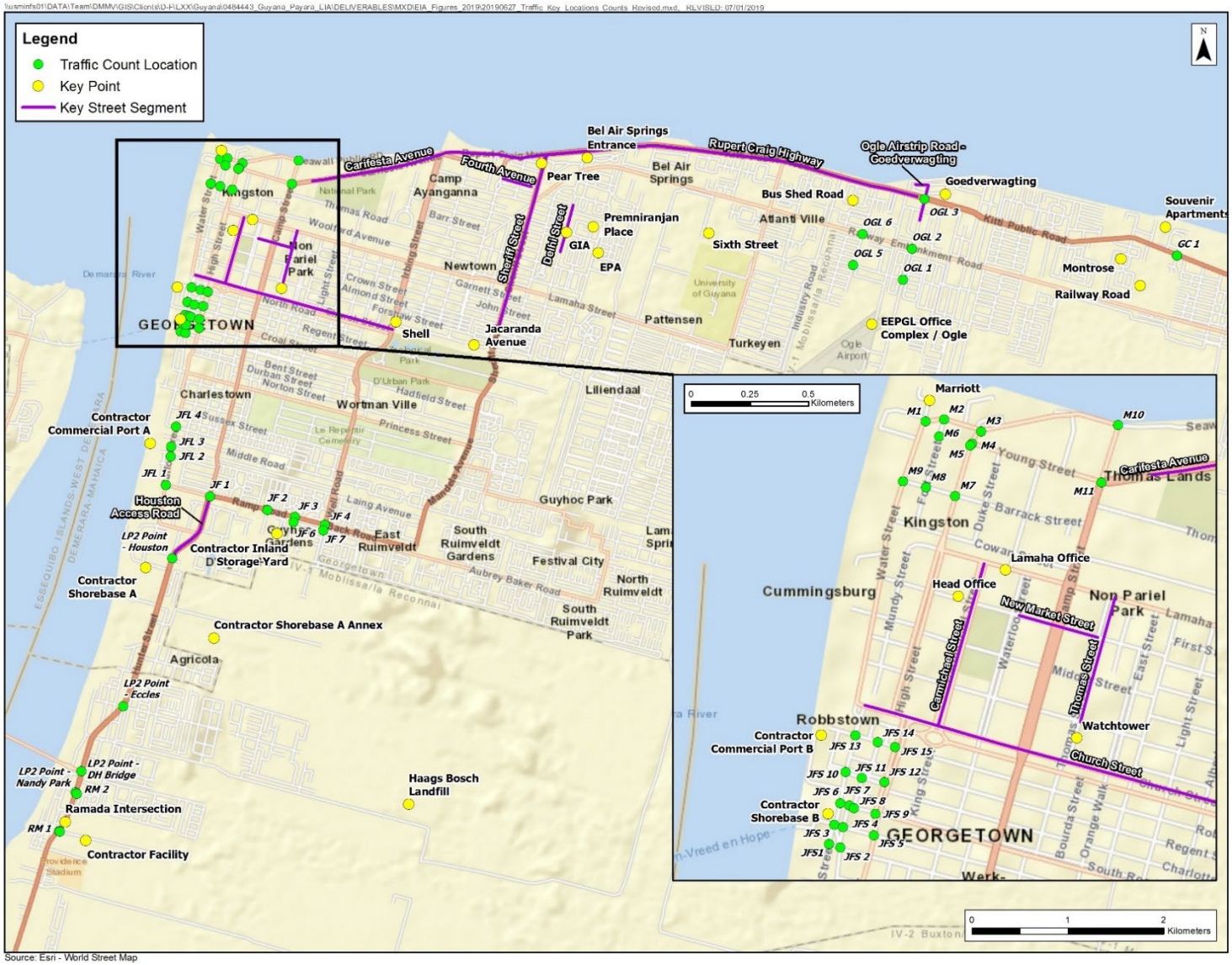


Figure 8.5-7: Key Points/Segments and Traffic Count Locations for 2026 LOS Modeling

Combining the EEPGL personnel and EEPGL non-personnel vehicle movements, Table 8.5-19 provides a summary of the key segments and estimated additional EEPGL-related daily trip-counts along the key segments (i.e., beyond the trip-counts recorded for the February to April 2019 period—which would be reflected in the measured base traffic counts) for 2026.

Table 8.5-19: Estimated Potential Additional EEPGL-related Intersection Crossings

Traffic Count Location	Estimated Potential Additional EEPGL-Related Intersection Crossings
	2026
LP2 Point Nandy Park	15
LP2 Point DH Bridge	15
LP2 Point Eccles	17
LP2 Point Houston	114
JFL-1	109
JFL-2	111
JFL-3	111
JFL-4	99
JF-1	109
JF-2	94
JF-3	94
JF-4	82
JF-6	12
JFS-1	17
JFS-2	17
JFS-3	17
JFS-4	17
JFS-5	96
JFS-6	8
JFS-7	8
JFS-8	8
JFS-9	87
JFS-10	8
JFS-11	8
JFS-12	87
JFS-13	8
JFS-14	8
JFS-15	87
M-1	52
M-2	44
M-3	62
M-4	69
M-5	69
M-6	0

Traffic Count Location	Estimated Potential Additional EEPGL-Related Intersection Crossings
	2026
M-7	60
M-8	0
M-9	38
M-10	9
M-11	326
GC-1	0
GC-2	434
GC-3	493
OGL-1	4
OGL-2	118
OGL-3	112
OGL-5	0
OGL-6	118

LOS modeling was then completed for the following scenarios:

- Conditions under the current road network in 2026—with assumed non-Project traffic growth (a.m. Peak and p.m. Peak); and
- Conditions under the current road network in 2026—with assumed non-Project traffic growth, with the inclusion of additional EEPGL-related traffic (a.m. peak and p.m. peak).

The full report containing the results of LOS modeling for these scenarios is included as Appendix T, Traffic Impact Assessment.

Considering both peak periods (a.m. and p.m.), all of the directions (e.g., northbound, southbound) and all of the turning movements (i.e., left, right, through) at each intersection, modeling predicted a total of 710 LOS ratings for each scenario. Comparing the results for the "without EEPGL vehicle movements" and "with EEPGL vehicle movements" scenarios, the LOS modeling predicted that the addition of projected EEPGL-related vehicle trips in 2026 would potentially shift an LOS rating from an "acceptable" LOS rating (i.e., LOS A-D) to a lower "acceptable" LOS rating for 29 out of 710 movements (approximately 4 percent) and from "acceptable" to "unacceptable" (i.e., LOS E-F) for 15 of the 710 movements (approximately 2 percent). This confirms that the additional EEPGL-related vehicle trip counts in 2026 are not expected to meaningfully change overall LOS ratings across the study intersections. On this basis, the intensity of impact on ground transportation at the as a result of planned Project activities is considered to be **Low**.

Potential impacts on ground transportation will be primarily limited to the **Direct AOI**. EEPGL-related vehicle movements will occur on a routine basis throughout the Project life cycle (at least 20 years), yielding a frequency designation of **Continuous** for all stages and a duration of **Long-term**.

Based on the definitions presented in Table 8.5-20, the magnitude of impact on ground transportation is considered to be **Small** during all Project stages.

Table 8.5-20: Magnitude of Impact—Ground Transportation

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
All Project stages	Road users, including drivers, cyclists, and pedestrians—increased vehicle traffic on public roads in and around Georgetown	Direct AOI (Georgetown and vicinity)	Low	Continuous	Long-term	Small

Sensitivity of Receptors—Ground Transportation

The receptors that could potentially experience impacts on ground transportation include current users of the Georgetown road network. Existing drivers will have a **Medium** level of sensitivity. This rating reflects the relatively high existing traffic volumes and congestion in the greater Georgetown area, as well as the lack of travel alternatives (i.e., other travel routes or modes of transportation) for non-Project drivers. Drivers already experience substantial traffic congestion and road safety risks in parts of Georgetown. Additional traffic will likely be viewed as incremental, but not a fundamental shift in conditions.

Impact Significance—Ground Transportation

Based on the magnitude of impact and receptor sensitivity ratings, the significance of ground transportation impacts on community stakeholders is **Minor**.

Magnitude of Impact—Air Transportation

The assessment of the Project's magnitude of impacts on air transportation is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on ground transportation is defined according to the definitions provided in Table 8.5-21.

Table 8.5-21: Definitions for Intensity Ratings for Potential Impacts on Air Transportation

Criterion	Definition
Intensity	Negligible: There are no anticipated measurable impacts on heliport capacity.
	Low: Impacts on heliport capacity are perceptible, but causing only rare instances of availability shortfalls.
	Medium: Impacts on heliport capacity are evident and lead to periodic availability shortfalls.
	High: Impacts on heliport capacity are sufficient to cause persistent availability shortfalls.

Logistical support will be optimized and shared among Liza Phase 1, Liza Phase 2, Payara, and Yellowtail. It is estimated that during development drilling and FPSO/SURF installation, helicopter flights may increase at peak to a total of approximately 20 to 25 round-trip flights per week. During FPSO/SURF production operations, an estimated five to seven round-trip flights

per week will be necessary to support production operations once development-drilling activities are complete.

As described in Section 2.12, End of Yellowtail Operations (Decommissioning), EEPGL has not prepared detailed plans for the decommissioning stage. As such, the level of air-transportation activity associated with decommissioning is not known. For purposes of impact analysis, air traffic associated with Project decommissioning is assumed to be similar to that of the drilling and installation stage.

During development drilling and FPSO/SURF installation, the level of helicopter activity (assuming a maximum of 25 round-trip flights per week) will represent approximately 7 percent of the total annual operational flight landings (using 2018 airport operational data as the base case). On this basis, EEPGL's level of helicopter activity is unlikely to meaningfully impact ECIA's heliport capacity or operations, but there could be rare instances of availability shortfalls. Accordingly, the magnitude of potential impacts on air transportation as a result of the Project is considered **Small**.

Sensitivity of Receptor—Air Transportation

Receptors for air transportation impacts include airport and airspace users and commercial, cargo, and private pilots, crew, and passengers. The aviation environment is highly regulated. Other air traffic, such as Project-related flights, is expected. All pilots are expected to be able to navigate in the presence of the limited additional Project-related aircraft. On this basis, air transportation users at ECIA are considered to have a **Low** level of sensitivity to increased air traffic from the Project.

Impact Significance—Air Transportation

Based on the magnitude of impact and receptor sensitivity ratings, the significance of air transportation impacts is **Negligible**.

8.5.4. Management Measures—Social Infrastructure and Services

Table 8.5-22 summarizes the embedded controls and mitigation measures relevant to social infrastructure and services. The development of impact-specific mitigation measures has focused on impacts with a predicted significance of minor or higher. Impacts with a negligible significance were not prioritized for mitigation, although they may also be addressed by other embedded controls or mitigation measures.

Table 8.5-22: List of Embedded Controls and Mitigation Measures

Embedded Controls
Implement a community safety program for potentially impacted schools and neighborhoods to increase awareness and minimize potential for community impacts due to vehicle incidents.
Coordinate with relevant aviation authorities and stakeholders to understand peak Project-related utilization rates.
Implement a Road Safety Management Procedure to mitigate increased risk of vehicular accidents associated with Project-related ground transportation activities. The Road Safety Management Procedure has been implemented as of the writing of this EIA, and the procedure includes the following components: • Definition of typical, primary travel routes for ground transportation in Georgetown area; • Development of an onshore logistics/journey management plan to reduce potential conflicts with local road traffic when transporting goods to/from onshore support facilities; • Definition of required driver training for Project-dedicated drivers, including (but not limited to) defensive driving, loading/unloading procedures, and safe transport of passengers, as applicable; • Designation and enforcement of speed limits through speed governors, global positioning system, or other monitoring systems for Project-dedicated vehicles; • Avoidance of deliveries during typical peak-traffic hours as well as scheduled openings of the Demerara Harbour Bridge, to the extent reasonably practicable; • Monitoring and management of driver fatigue; • Definition of vehicle inspection and maintenance protocols that include all applicable safety equipment for Project-dedicated vehicles; and • Community outreach to communicate information relating to major delivery events or periods.
Mitigation Measures
Proactively communicate the Project's limited staffing requirements as a measure to reduce the magnitude of potential population influx to Georgetown from job seekers.
Communicate EEPGL's health, safety, and security standards and requirements to interested hotel owners.

8.5.4.1. Lodging

No mitigation measures are required to address potential impacts on lodging. However, the Project can proactively communicate EEPGL's health, safety, and security standards and requirements to interested hotel owners across the Georgetown area. With this knowledge, hotels that have not traditionally been used by the Project workforce may be able to improve standards and be considered for future use. This could have the desired outcome of spreading Project workforce hotel room demand across a wider range of hotels and therefore decreasing the intensity of the potential impact on both hotel room demand and potential resultant increases in price.

Table 8.5-23 summarizes the assessment of potential pre-mitigation and residual Project impacts on lodging. The significance of impacts was assessed based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the lodging-specific methodology described above.

8.5.4.2. Housing and Utilities

No mitigation measures are required to address potential impacts on housing and utilities. However, the Project will proactively manage messaging about the Project's limited workforce needs to stakeholders to reduce the potential for induced population influx.

Table 8.5-24 summarizes the assessment of potential pre-mitigation and residual Project impacts on housing and utilities. The significance of impacts was assessed based on the general impact assessment methodology described in Chapter 4, as well as the housing and utilities-specific methodology described above.

8.5.4.3. Ground and Air Transportation

Beyond the embedded controls listed above (which include implementation of a Road Safety Management Procedure with elements that will serve to reduce potential Project-related contributions to traffic congestion), no additional mitigation measures are proposed to address potential impacts on ground and air transportation.

Table 8.5-25 below summarizes the assessment of potential pre-mitigation and residual Project impacts on ground and air transportation. The significance of impacts was assessed based on the general impact assessment methodology described in Chapter 4, as well as the ground and air transportation-specific methodology described above.

Table 8.5-23: Summary of Potential Pre-Mitigation and Residual Impacts—Lodging

Stage	Resource/Receptor Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Drilling SURF and FPSO Installation, Commissioning, and Start-up	Leisure and business travelers to Guyana, specifically Georgetown and vicinity—Increased demand or use of lodging, leading to reduced availability and/or increased cost	Small	Medium	Minor	Communicate EEPGL's health, safety, and security standards and requirements to interested hotel owners	Minor
Production Operations Decommissioning	Leisure and business travelers to Guyana, specifically Georgetown and vicinity—Increased demand or use of lodging, leading to reduced availability and/or increased cost	Negligible	Medium	Negligible	Communicate EEPGL's health, safety, and security standards and requirements to interested hotel owners	Negligible

Table 8.5-24: Summary of Potential Pre-Mitigation and Residual Impacts—Housing and Utilities

Stage	Resource/Receptor Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Drilling SURF and FPSO Installation, Commissioning, and Start-up	General population of Georgetown and vicinity—decreased availability/increased cost of housing and utilities	Small	Medium	Minor	Proactive messaging regarding Project employment opportunities	Minor
Production Operations Decommissioning	General Georgetown population and vicinity—decreased availability/increased cost of housing and utilities	Negligible	Medium	Negligible	None	Negligible

Table 8.5-25: Summary of Potential Pre-Mitigation and Residual Impacts—Ground and Air Transportation

Stage	Resource/ Receptor—Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	Ground transportation: Non-Project drivers—increase in traffic congestion	Small	Medium	Minor	None	Minor
All Project stages	Air transportation: Non-Project users of ECIA—interference with heliport use	Small	Low	Negligible	None	Negligible

8.6. WASTE MANAGEMENT INFRASTRUCTURE CAPACITY

8.6.1. Administrative Framework—Waste Management Infrastructure Capacity

Table 8.6-1 summarizes the legislation, policies, or treaty commitments that are specifically relevant to the assessment of potential impacts on waste management infrastructure capacity.

Table 8.6-1: Legislation, Policies, or Treaty Commitments—Waste Management Infrastructure Capacity

Title	Objective	Relevance to the Project
Legislation		
Environmental Protection Hazardous Waste Regulations (2000)	Establishes requirements for generating, handling, and disposing of hazardous waste as well as penalties for violations of these requirements.	Identifies wastes subject to regulation, including several types of waste that could be generated as part of the Project.
Policies and Strategies		
National Solid Waste Management Strategy (Under Development)	Guides the Government of Guyana's agenda on waste collection, transportation, and disposal; goals include improving the waste management infrastructure, enforcing existing legislation, and promoting waste-to-energy initiatives. Will inform the country's integrated efforts at converting waste material into useful resources and aims to ensure their full utilization and eventual exploitation as by-products. Currently under development.	Once the strategy is approved, it is expected to apply to the collection, transportation, and disposal of Project-generated waste.
International Agreements		
IMO International Maritime Dangerous Goods Code (2018 edition)	Governs maritime transport of wastes worldwide; addresses classifications of dangerous goods, packing and tank provisions, consignment procedures, construction and testing of packaging, IBCs, portable tanks, and transport operations.	Applies to all marine vessels that will transport wastes generated as part of the Project.
International Agreements Signed / Acceded by Guyana		
Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal (1989)	Identifies conditions on the import and export of hazardous wastes, including requirements for notice, consent, and tracking for movement of wastes across international boundaries.	Would apply to the Project only if hazardous waste generated in Guyana is disposed outside Guyana. Currently, the convention is not relevant, as EEPGL does not import or export hazardous wastes. Guyana acceded in 2001.

IMO = International Maritime Organization

8.6.2. Existing Conditions—Waste Management Infrastructure Capacity

8.6.2.1. Waste Management Authorities

Currently, several public sector agencies are involved in waste management in Guyana, including the EPA, Ministry of Local Government and Regional Development (MLGRD), Ministry of Public Health, Ministry of Natural Resources, RDCs, NDCs, and TCs, and there are some overlaps in roles and responsibilities. The two key organizations involved in waste management are the EPA and the MLGRD; their roles in waste management are further elaborated below.

Guyana Environmental Protection Agency

The EPA is responsible for permitting waste disposal sites. In addition, waste management is one of the EPA's program areas. Under the EPA's Industry/Waste Management program area, the EPA manages the policies, guidelines, and standard operational procedures regarding waste management and resource recovery. The stated aim of the program is to realize maximum value from natural resources and ensure a "green environment."

The core function of the Waste Management sub-program within this program area is to manage waste entering into the environment in an environmentally sound manner. Through this program area, the EPA provides technical assistance in the development, management, and operation of waste management facilities; conducts research and analysis on the recovery of useful energy from solid waste; and develops guidelines and standards for the disposal of hazardous waste and other types of waste. Through the same program area, the EPA also coordinates and implements the obligations of the Basel Convention and controls the import and export of hazardous waste through granting of authorizations. The waste management component of the program area focuses on three topics:

- Solid waste management
- Hazardous waste management
- Waste reduction and recovery

Since 2020, the EPA has been developing a draft set of requirements for hazardous and non-hazardous waste management, which is understood will eventually become part of revised waste regulations. Accordingly, it is envisioned that waste service providers' operations may need to be updated in the future. It is understood that one of the major revisions to these regulations will be the adoption of U.S. Resource Conservation and Recovery Act-like disposal treatment standards.

Ministry of Local Government and Regional Development

The MLGRD is the primary government agency that links the various local authorities with the central Government of Guyana. It facilitates, coordinates, and monitors the execution and implementation of a number of projects, programs, and activities in the various local government arms and ensures that these activities are in conformity with the legal framework and the policies of the government. This ministry is also leading development of the National Solid

Waste Management Strategy referenced in Table 8.6-1. The MLGRD has direct oversight over the Haags Bosch Landfill (HBL) site, as well as the waste management activities of RDCs, NDCs, the Georgetown City Council, and TCs.

8.6.2.2. Municipal/Non-hazardous Waste Management Facilities

In Region 4, the HBL, which is located in Eccles East Bank Demerara area, is government-owned under the jurisdiction of the MLGRD (Sanitation Management Unit) and is operated by a third-party contractor—Waste Solutions Landfill Inc. (joint venture between Puran Brothers and Cevons Waste Management). The HBL started operations in early 2011. At present, the HBL is the only engineered landfill in Guyana for the disposal of municipal solid waste and non-hazardous commercial/industrial wastes. The HBL is the current destination for most municipal and commercial solid non-hazardous waste generated from the greater Georgetown area, including wastes generated from the more than 25 NDCs between Mahaica, the Seawall, Timehri, and Parika.

The original HBL disposal cell (Cell 1) is at capacity, and a second cell (Cell 2) started operations in late March 2021 (Damon 2021). The HBL facility currently receives approximately 500 tonnes of waste per day. At current disposal rates, the Government of Guyana estimates that Cell 2 has approximately 4 to 6 years of disposal capacity. This estimated life span of Cell 2 depends upon how much the waste volumes received at the landfill increase with the expanded economic development expected in the Georgetown area over the next 5 years. There remains space for additional cell(s) at the HBL location to be developed in the future.

The currently available landfill capacity appears sufficient to support the Project and other users for the short term, even considering forecasted growth in waste volumes from expanding industrial activity. Presuming additional cell(s) would be constructed on a timely basis, the future HBL capacity also appears reasonable for the longer-term (up to 10 years).

Aside from the HBL in Region 4, most regions in Guyana rely on dumpsites for the disposal of municipal waste, with each region having at least one dumpsite. In addition to receiving municipal waste from household collections, these dumpsites are also used for the disposal of commercial and industrial waste. Although the dumpsites are intended only for the disposal of non-hazardous wastes, the control over incoming waste is generally not rigorous.

The Government of Guyana is seeking to develop a more coordinated approach to waste infrastructure planning that is compatible with land use planning and promotes coordination and optimization of waste management facilities across all regions. The Ministry of Communities' (predecessor to MLGRD) stated strategy in 2017 was to progressively rehabilitate illegal dumpsites, disused dumpsites, and poorly operated dumpsites (Gilkes 2017). In 2019, the government's Sanitation Unit collaborated with the EPA to embark on a number of assessments of existing dumpsites and proposed landfill sites in each administrative region across Guyana. The project was working toward a countrywide sustainable waste management system. The MLGRD has controlled dumpsites at Lusignan in Region 4; Byderabo in Bartica; Rose Hall; Esplanade in New Amsterdam; and Bon Success in Lethem. In early 2021, the government announced it would be moving to create temporary regional dumpsites in Regions 2, 3 and 5 in

2021. The creation of the dumpsites is covered under a $1.1 billion GYD ($5,500,000 USD) line item allocated for solid waste management in the 2021 national budget. The allocation also included funds for completion of Cell 2 construction at the HBL Site and disposal sites upgrade at Rose Hall, Port Kaituma, Belle Vue, Lethem, Lima, Charity, Lusignan, and D'Edward village (Garnett 2021).

8.6.2.3. Industrial/Hazardous Waste Management Facilities

There is a limited number of facilities for the treatment of hazardous and industrial waste in Guyana, although the construction and proposal of additional such facilities are growing commensurate with the planned expansion of oil and gas activities. Tiger Rentals Guyana Inc. (TRG), located at the Guyana Shorebase Inc. (GYSBI) facility, is currently the primary provider of hazardous and non-hazardous waste treatment services in Guyana. TRG employs a variety of waste treatment technologies (sorting/segregation of recyclables, physical/chemical/thermal treatment of hazardous and non-hazardous wastes), discharges its treated fluids as permitted to the Demerara River, and sends its treated non-hazardous solid waste as well as other wastes received (including general waste, paper/cardboard, and scrap wood) to the HBL.

In addition to TRG, several additional private waste management facilities have come online or are expected to come online in the near-term for hazardous (and non-hazardous) waste treatment, including the following:

- Eternity Investment Inc. (EII) is a scrap metal consolidation and exporting facility that also accepts and manages lead acid batteries and electronic waste. EII is currently the only facility authorized by the EPA to manage electronic wastes. The main scrap yard for the facility is located in a sparsely developed area of Madewini near the Cheddi Jagan International Airport. The company receives non-ferrous (including lead acid batteries), ferrous, and electronic waste scrap, and then sorts and consolidates these materials. These materials are packaged in sea-going containers and exported to buyers worldwide. EII receives scrap metal from throughout Guyana.
- Sustainable Environmental Solutions Guyana, Inc. (SES) has constructed a new integrated waste management facility at GYSBI for managing wastes generated from offshore oil and gas operations; this facility went operational in 4Q 2021. The facility employs various hazardous and non-hazardous waste management technologies, including hot oil thermal desorption, incineration, decanter/centrifuge separation, wastewater treatment, waste shredding, container crusher/baling, and container washing operations.
- Liquid Mud Plants (LMPs) (of which there are currently three) are operated by onshore drilling services providers that operate cement and drilling fluids facilities, including Schlumberger Guyana, Inc. / MI-Swaco (located at the GYSBI facility), Halliburton Guyana, Inc. (located at the G-Port facility at the mouth of the Demerara River), and Baker Hughes Guyana Inc. (also located at the G-Port facility). The LMPs manufacture drilling fluids (mud) for offshore oil and gas operations, but also receive spent mud from the offshore drilling operations for onshore reconditioning. The used muds are reclaimed using mechanical (centrifugation) and chemical processes, and the reconditioned muds are then returned to

the drill ships for use in new drilling operations. The LMPs generate hazardous and non-hazardous wastes from their reconditioning operations, including fluids, cuttings, and other solids recovered from the used muds, as well as other operational wastes (e.g., wastewaters, oily rags, general refuse). Until recently, these wastes have been managed by TRG. In 3Q 2021, the SES facility (see above) commissioned thermal desorption and incinerator operations and began receiving centrifuge solids from the LMPs. Commissioning of wastewater treatment operations at the SES facility is forecasted for 1Q 2022.

- Oilfield Waste Management Services (OWMS) submitted a permit application to the EPA in 2020 for the construction of a 5,000-square-meter (approximately 53,820-square-foot) drilling waste processing plant in the Little Diamond East Bank Demerara area (located approximately 5 kilometers [approximately 3 miles] south of GYSBI). OWMS will employ thermal desorption separator (hammer mill) technology to treat drilling muds. Oil and water recovered from the process are proposed to be recycled in the formulation of new drilling muds, and the solids are proposed to be used in the bitumen manufacturing process or sent to the HBL. It is unknown when the OWMS plant will become operational.
- Environmental Waste Management Services Guyana Inc. submitted a permit application in late 2020 for the construction and operation of a waste treatment (bioremediation) facility for mud sludge generated from activities in the oil and gas sector. The proposed facility location is at Lots 21 and 22, Block XXV111 Zone Plantation Friendship, East Bank Demerara area. According to the EPA Public Notice issued December 2020, the operation will involve the development of two treatment ponds lined with high-density polyethylene geomembrane liners and contained by 91.4-centimeter-high (approximately 36-inch-high) berms. The status of this application is not currently known, and it is also unknown when the facility would become operational.
- GYSBI currently operates a steel pipe warehouse, storage, and handling operation at its Annex location that involves the washing of virgin steel pipe prior to transfer to the wharf and loading onto the vessels for offshore transit. The non-hazardous effluent from this washing operation is currently collected and treated in on-site evaporators, with no discharge of this effluent. This location is being considered as part of a feasibility assessment for developing a new facility to exclusively manage used plastic drill pipe thread protectors generated from the pipe handling operations. Pipe thread protectors are designed to protect the critical threads of the steel pipes during storage, handling, and transport; tens of thousands of these metal-reinforced plastic caps will be generated as a result of offshore well installation operations. These used plastic caps will first be subject to grinding to separate the plastic and metal parts, and the plastic will then be melted and pelletized and returned to the original manufacturer as a raw material for the production of new plastic caps. The recovered metal will also be recycled. Although being considered, it is uncertain when this type of facility would move forward at this location.

At present, all marine support vessel (MSV) tank-cleaning operations are conducted in Trinidad; the cleaning process employed in Trinidad is manual and generates large volumes of wash water and solids. In the future, the SES facility (see above) will provide tank-cleaning services in

Guyana using technologies that reduce the generation of waste. The SES tank-cleaning system design includes a solids removal system and wash water reuse technology. The solids removal system and wash water reuse technology selected will reduce the waste generated from tank cleaning. The waste stream volumes generated from this system are expected to be treated by the wastewater treatment system and thermal desorption unit that SES will operate. The expected start-up for MSV tank cleaning capabilities at the SES facility in Guyana is 2Q 2022. Material recovered from tank cleaning services can be evaluated for reuse at LMPs. The operation of three LMPs in Georgetown to efficiently support offshore operations requires co-located tank cleaning services.

8.6.3. Impact Assessment—Waste Management Infrastructure Capacity

Various Project waste streams generated offshore will be treated and/or discharged directly to the sea in accordance with applicable international standards. All of these waste streams are subject to some type of pre-treatment and/or monitoring prior to discharge overboard in accordance with permit requirements, international conventions, relevant international standards, or good international oilfield practice. Further details about waste streams discharged to the sea are presented in Section 2.13.3, Discharges. Potential impacts of Project discharges to sea are discussed in Section 6.4.3, Impact Assessment—Marine Water Quality, and Section 6.4.4, Management Measures—Marine Water Quality.

The remainder of this section focuses on Project-generated wastes that will be transported for management onshore.

8.6.3.1. Relevant Project Activities and Potential Impacts

The types and quantities of Project-generated wastes that will be transported for management onshore are detailed in Section 2.13.4, Wastes, and summarized below in Table 8.6-2.

All wastes generated by the Project will be managed in accordance with a Comprehensive Waste Management Plan (CWMP) that will be used for the management of all EEPGL waste. The CWMP, which has been approved by the EPA, lists in detail the specific types of wastes that will be generated by the Project and their sources. It specifies the primary and alternative treatment/disposal methods for each waste, as well as the associated monitoring and reporting requirements. The CWMP also indicates the roles and responsibilities of the different parties involved in managing Project wastes, and the national and international waste management regulations and good international oilfield practice that are applicable to management of wastes from the Project.

Table 8.6-2: Summary of Estimated Annual Generation for Project Wastes that will be Managed Onshore

Waste Generated by Category	Volume by Year/Metric Tonnes [a]									
	2023	2024	2025	2026	2027	2028	2029	2030	2031-2032	2033-2045
Non-Hazardous wastes (total) [b, c]	750	1,900	2,030	1,670	1,670	1,670	1,670	110	1,670	110
Hazardous wastes (total) [b, d]	300	2,360	3,270	700	700	700	700	100	700	100

[a] The annual totals reflect the current preliminary Project schedule and production profile, which could change. Totals conservatively assume three drill ships are supporting the Project continuously throughout the drilling timeline indicated on the preliminary Project schedule.
[b] Totals may not sum exactly due to rounding.
[c] Includes wastes that will be directly shipped to an approved landfill and wastes that can be recycled, reclaimed, or reused. Volumes include estimated quantities of residue from treatment of hazardous waste.
[d] Includes wastes that are treated to produce residual non-hazardous effluent than can be discharged through permitted outfalls; and wastes that are treated to produce residual non-hazardous solid wastes that can then be recycled, reclaimed, or reused, or transported for disposal in an approved landfill.

Consistent with the CWMP, the Project will follow the principles of the waste management hierarchy[29] and will, as far as practical, take steps to avoid and minimize the generation of waste, maximize the amount of waste that is reused and recycled, and minimize the amount of waste that needs to be disposed (and in particular landfilled). The CWMP provides details as to how different types of waste are to be handled, stored, and transported to shore to avoid potential environmental, health, and safety issues. Specifically, it describes how different types of waste will be segregated, the types of containers that will be used, and the labeling requirements for waste containers. All transfers of waste from offshore Project facilities to shorebases will be covered by marine transport manifests and will be undertaken in suitably licensed vessels. Any on-land transfers of waste will similarly be covered by use of waste transfer documentation so that movements of waste can be tracked through to the point of final disposal.

A range of different onshore treatment and disposal methods will be used for the different types of Project wastes, as follows:

- Third-party waste contractor(s) will treat wastes onshore using thermal treatment methods such as thermal desorption and/or stabilization technologies to treat hazardous solid wastes, and thermal oxidation or filtration and separation to treat effluent. Treated effluent will be discharged through permitted outfalls to the Demerara River. Only contractors that are

[29] The waste management hierarchy used by EEPGL is as follows: (1) Generation of waste should be Avoided, Prevented, or Reduced at the source whenever feasible; (2) Wastes that are not Avoided or Prevented should be Reused or Recycled in an environmentally safe manner, whenever feasible; (3) Wastes that are not Avoided, Prevented or Recycled/Reused should be Treated in an environmentally safe manner, whenever feasible; and finally, (4) Disposal should be employed as a last option and, when employed, should be conducted in an environmental responsible manner (OGP 2009).

appropriately licensed by the EPA and have been assessed by EEPGL as being of a sufficient standard will be used to treat the Project's wastes.

- Ash from the incineration of waste, residual solid waste from treated hazardous solid wastes, and general non-hazardous wastes will be taken to a landfill that has been appropriately licensed by the EPA and assessed by EEPGL as being of a sufficient standard. Currently, the only Georgetown-based facility EEPGL has identified as meeting these requirements is the HBL.
- Specific wastes that can be recycled locally, such as scrap metal and electronic waste, will be taken to approved local recyclers.

Any new or unanticipated wastes, such as from an emergency response, will be assessed to determine the most appropriate handling/on-site management and treatment/disposal methods.

The Project will manage its wastes in accordance with national and international waste management regulations and good international oilfield practice, as described in the CWMP. EEPGL will use waste contractors that are licensed by the authorities, and will undertake its own assessments to assess whether contractors are operating to international environmental and health and safety standards.

8.6.3.2. Magnitude of Impact—Waste Management Infrastructure Capacity

The assessment of the Project's magnitude of potential impacts on waste management infrastructure capacity at all stages of the Project is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on waste management infrastructure capacity is defined according to the definitions provided in Table 8.6-3.

Table 8.6-3: Definitions for Intensity Ratings for Potential Impacts on Waste Management Infrastructure Capacity

Criterion	Definition
Intensity	Negligible: Anticipated Project waste volumes will not contribute significantly to driving demand for the capacity of existing waste management infrastructure, or will contribute significantly to driving a demand but that demand is well within the existing waste management infrastructure capacity.
	Low: Anticipated Project waste volumes will contribute significantly to driving a demand that could exceed the existing waste management infrastructure capacity, but that would be within the reasonably anticipated waste management infrastructure capacity.
	Medium: Anticipated Project waste volumes will contribute significantly to driving a demand at or slightly beyond the reasonably anticipated waste management infrastructure capacity.
	High: Anticipated Project waste volumes will contribute significantly to driving a demand that is well beyond the existing or reasonably anticipated waste management infrastructure capacity.

As noted above, EEPGL routinely reviews its contracted waste management facilities to ensure they are of a sufficient quality to manage its wastes. These reviews include routine audits that cover a range of topics (e.g., financial, environmental, safety, security, health), as well as periodic assessments that are focused on more specific topics, such as infrastructure capacity

as described further below. In 2018 and 2019, EEPGL conducted audits of the TRG facility and the HBL facility, and both facilities were assessed as operating at a sufficient quality level to continue managing EEPGL's wastes.

In May 2019, EEPGL conducted a capacity assessment of the TRG facility, with the specific objective of assessing whether the facility had any potential constraints that could challenge its ability to accommodate EEPGL's anticipated waste streams. The results of the assessment indicated that, without modifications, the infrastructure capacity of the facility would likely be unable to keep up with treating the increased volume of EEPGL's hazardous solids and waste oil liquids anticipated to be generated by future EEPGL activities.

Since the May 2019 capacity assessment, there has been significant expansion of third-party commercial hazardous waste handling, storage, and treatment facilities in Georgetown. This has included the addition of a pug mill (for waste stabilization), an additional thermal treatment unit, and a wash bay with pre-/post-treated water storage (for waste treatment) at the TRG facility. Construction is continuing at the TRG facility to add a further 2,000-barrel (318,000-liter) treated water storage tank, additional thermal treatment capacity, additional pug mill facilities, and storage for post-treatment solids. Additionally, as noted above, SES has developed an integrated waste management facility that became operational in 2021; this will provide additional capacity for management of both hazardous and non-hazardous wastes.

Several additional qualified third-party waste management operators are currently seeking authorization for facility developments or expansions, as discussed above. These are expected to further expand the capacity of onshore waste management infrastructure to manage the Project's hazardous, non-hazardous, and exempt hazardous waste storage, processing, treatment, and/or recycling needs.

All non-hazardous solid wastes generated to date from EEPGL's projects and managed onshore have been disposed at the HBL, and this is the plan for management of these wastes from the Project. EEPGL's contributions of non-hazardous solid waste volumes sent to the HBL have been averaging on the order of 30 to 35 tonnes per day, which represents approximately 6 to 7 percent of the total non-hazardous waste volumes received by the HBL on a daily basis (approximately 500 tonnes per day).

As discussed above, at current disposal rates, the recently opened Cell 2 of the HBL will have approximately 4 to 6 years of disposal capacity. However, with an increase in offshore activity expected, along with potential for growth in other industrial and commercial sectors, the quantity of wastes going to the HBL is expected to increase going forward. Considering these factors, the currently available landfill capacity appears sufficient for the short-term (2 to 3 years), even considering forecasted growth in waste volumes from industrial use. Presuming the additional HBL cell(s) discussed above would be constructed on a timely basis, the future HBL capacity also appears reasonable for the longer-term (up to 10 years). If it becomes apparent that suitable additional capacity at the HBL would not be available to support EEPGL's needs, EEPGL would pursue plans to construct an alternative industrial landfill to meet anticipated needs.

As residential and commercial development and infrastructure grow in the vicinity of HBL, new landfill development in the region may be appropriate going forward. Subsequent decisions as to further expansion of existing or development of new municipal waste landfills will be undertaken by the Government of Guyana with the input and support of the MLGRD and the EPA and participation of the public and other stakeholders.

Balancing the above-noted recent and ongoing expansions of hazardous waste treatment infrastructure capacity with the fact that the Project will be a significant contributor to hazardous waste treatment demand—in particular during development well drilling—the intensity of potential Project impacts on Georgetown-based hazardous waste treatment facilities is considered to be as much as **Medium**. Potential impacts will be limited to the **Direct AOI** (i.e., Georgetown). Waste management and disposal will take place throughout the entire Project life cycle (at least 20 years), yielding a frequency designation of **Continuous** for all stages. Duration will be **Long-term** for all Project stages. Therefore, the magnitude of the Project's potential impact on hazardous waste management infrastructure capacity is rated as **Medium** (see Table 8.6-4).

The Project's projected peak waste generation is on the order of approximately 450 tonnes per month (non-hazardous and hazardous combined; see Table 8.6-2). Conservatively assuming all of the non-hazardous waste and all of the treated hazardous waste (assuming no reduction in mass during treatment), this represents approximately 3 percent of the total current demand on Georgetown-based landfill facilities (on the order of approximately 15,000 tonnes per month). Taking into consideration the opening of Cell 2, the reasonably anticipated development of additional cell(s) at the HBL, and the limited percent contribution of the Project, the intensity of potential Project impacts on non-hazardous waste management infrastructure capacity is considered to be no more than **Low**. Potential impacts will be limited to the **Direct AOI** (i.e., Georgetown). Waste management and disposal will take place throughout the entire Project life cycle (at least 20 years), yielding a frequency designation of **Continuous** for all stages. Duration will be **Long-term** for all Project stages. Therefore, the magnitude of this potential impact is rated as **Small** (Table 8.6-4).

Table 8.6-4: Magnitude of Impact—Waste Management Infrastructure Capacity

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
All Project stages	Waste Management Infrastructure and Capacity (non-Project users of Georgetown-based hazardous waste treatment facilities)—exceedance of capacity	Direct AOI (Georgetown)	Medium	Continuous	Long-term	Medium
All Project stages	Waste Management Infrastructure and Capacity (non-Project users of Georgetown-based non-hazardous waste treatment [landfill]	Direct AOI (Georgetown)	Low	Continuous	Long-term	Small

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
	facilities)—exceedance of capacity					

8.6.3.3. Sensitivity of Receptors—Waste Management Infrastructure Capacity

Potential receptors for waste management infrastructure capacity impacts include non-Project users of Georgetown-based hazardous waste management facilities (principally, other oil and gas-related companies) and Georgetown-based non-hazardous waste management facilities (i.e., the general Georgetown community). The sensitivity ratings for these receptors are defined in Table 8.6-5.

Table 8.6-5: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Waste Management Infrastructure Capacity

Criterion	Definition
Sensitivity	Low: The receptor is able to adapt to impacts on waste management infrastructure capacity with no outside assistance or mitigation.
	Medium: The receptor is able to adapt to impacts on waste management infrastructure capacity, but requires some outside assistance or mitigation to do so.
	High: The receptor cannot adapt to impacts on waste management infrastructure capacity, even with outside assistance or mitigation.

Table 8.6-6 summarizes the sensitivity ratings assigned for the primary receptors that could potentially experience impacts on waste management infrastructure capacity from planned activities of the Project.

Table 8.6-6: Sensitivity Ratings for Receptors of Potential Impacts on Waste Management Infrastructure Capacity

Receptor	Sensitivity Rating	Rationale for Rating
Non-Project users of Guyana-based hazardous waste management facilities	Low	Non-project users of Guyana-based hazardous waste treatment facilities are largely limited to other oil and gas exploration/production or oil and gas industry support companies. These companies have the ability to access alternate regional providers for this service, albeit likely at an increased cost and a commensurate reduction in their operational efficiency.
Non-Project users of Guyana-based non-hazardous waste management facilities (landfills)	High	Non-project users of Guyana-based landfills include other industrial waste generators, as well as the general Georgetown-area community. Focusing on the latter, the general Georgetown-area community currently has no feasible alternative options for the proper management of its municipal wastes.

8.6.3.4. Impact Significance—Waste Management Infrastructure Capacity

Based on the magnitude of impact and receptor sensitivity ratings, the pre-mitigation significance of potential Project impacts on waste management infrastructure capacity is **Minor** for non-Project users of Georgetown-based hazardous waste treatment facilities and **Moderate**

for non-Project users of Georgetown-based non-hazardous waste management infrastructure (i.e., landfills).

8.6.4. Management Measures—Waste Management Infrastructure Capacity

Although the Project itself is not considered a receptor for the purpose of the EIA, the viability of its operations depends on reliable access to waste management infrastructure of a sufficient quality and with sufficient capacity. In view of this need, and in recognition of the pre-mitigation significance ratings for potential impacts on non-Project users, the Project has initiated the following mitigation measures:

- As warranted based on anticipated future EEPGL hazardous waste generation trends and trends in non-EEPGL hazardous waste generation, continue enabling the expansion of existing local waste management capacity for hazardous wastes, and explore use of new local hazardous waste treatment facilities, or identify suitable alternative solutions.
- Continue monitoring plans for further expansion of the HBL and/or (if approved by the EPA) construction of additional landfill sites in other locations (as decided by the government), or identify suitable alternative (interim) local solutions for non-hazardous waste management.

In addition to these mitigation measures, additional EEPGL waste management-related embedded controls are further summarized below and in the CWMP.

Assuming implementation of these mitigation measures and embedded controls, and progress made to date, the intensity ratings for potential Project impacts on waste management infrastructure capacity will reduce to no more than **Low** for Georgetown-based hazardous waste management facilities and **Negligible** for Georgetown-based non-hazardous waste management facilities (HBL). This results in reduced magnitude ratings of **Negligible** for both receptor types, yielding residual significance ratings of **Negligible** for both receptor types. However, in view of the fact that capacity expansions for the HBL and/or construction of additional landfill sites in Georgetown are not under EEPGL's control, the residual significance rating for potential impacts on Georgetown-based non-hazardous waste management capacity is set at a level of **Minor**.

Table 8.6-7 summarizes the embedded controls, mitigation measures (inclusive of the measures listed above), and monitoring measures relevant to this receptor.

Table 8.6-7: List of Embedded Controls, Mitigation Measures, and Monitoring Measures

Embedded Controls
For transport of hazardous wastes off site for treatment or disposal, confirm that the waste is accompanied by a manifest signed by the hazardous waste generator and transporter.
Provide for adequate onshore waste management equipment and facilities for the proper management of waste in accordance with local regulation and good international oil field practice.
For wastes that cannot be reused, treated, or discharged/disposed on the drill ships or FPSO, properly manifest and transfer such wastes to appropriate onshore facilities for management.
Periodically audit waste contractors to verify appropriate waste management practices are being used.

Avoid, reduce, and reuse/recycle wastes preferentially prior to disposal in accordance with the waste management hierarchy.
Perform onshore waste treatment for certain categories of waste, thereby reducing demand on landfill capacity.
Mitigation Measures
To address future waste capacity constraints in Georgetown relative to Project's predicted waste management needs: • As warranted based on anticipated future EEPGL hazardous waste generation trends and trends in non-EEPGL hazardous waste generation, continue enabling the expansion of existing local waste management capacity for hazardous wastes, and explore use of new local hazardous waste treatment facilities, or identify suitable alternative solutions. • Continue monitoring of plans for further expansion of the HBL and/or (if approved by the EPA) construction of additional landfill sites in other locations (as decided by the government), or identify suitable alternative (interim) local solutions for non-hazardous waste management.
Monitoring Measures
Record type and quantity of each individual waste stream on board vessels any time a new waste is generated.
Inspect on a regular basis waste storage areas and containers; log inspections.
Document marine waste transfers.
Sample and perform analytical testing as needed to properly classify waste.
Complete Recoverable Material and Waste Summaries.
Complete and submit reports as per permit requirements.
Conduct waste facility audits and inspections periodically.

Table 8.6-8 below summarizes the assessment of potential pre-mitigation and residual Project impacts on waste management infrastructure capacity. The significance of impacts was assessed based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the resource-specific methodology described above.

Table 8.6-8: Summary of Potential Pre-Mitigation and Residual Impacts—Waste Management Infrastructure Capacity

Stage	Resource/Receptor Impact	Magnitude Rating	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	Waste Management Infrastructure and Capacity (non-Project users of Georgetown-based hazardous waste treatment facilities) – exceedance of capacity	Medium	Low	Minor	See Section 8.6.4	Negligible
All Project stages	Waste Management Infrastructure and Capacity (non-Project users of Georgetown-based landfill facilities) – exceedance of capacity	Small	High	Moderate	See Section 8.6.4	Minor

8.7. CULTURAL HERITAGE

"Cultural heritage" is an umbrella term for many heritage-related resources defined by international organizations as well as national laws and regulations. Guyana's National Trust Act of 1972 protects national monuments, defined as resources of "historic, architectural or archaeological interest attaching to it or its national importance." According to this law, the National Trust of Guyana is responsible for declaring resources to be national monuments.

Cultural heritage can be both tangible and intangible (e.g., oral histories), and tangible cultural heritage can be both portable (i.e., objects) and non-portable (i.e., sites). Non-portable, tangible cultural heritage, the type typically most susceptible to impacts from development projects, can be further subdivided into archaeological, architectural, and living heritage sites. Archaeological sites are areas where human activity has measurably altered the earth or deposits of physical remains are found (e.g., artifacts). Archaeological sites can be prehistoric or historic, and can be underwater or terrestrial. Architectural sites include standing buildings, bridges, dams, and other structures of historic or aesthetic significance. Living heritage consists of resources of traditional, religious, or cultural significance. Living heritage sites can include archaeological resources, sacred sites, sacred structures, and prominent topographical features essential for the preservation of traditional cultures.

8.7.1. Administrative Framework—Cultural Heritage

Table 8.7-1 summarizes the legislation, policies, or treaty commitments that are specifically relevant to the assessment of potential impacts on cultural heritage.

Table 8.7-1: Legislation, Policies, or Treaty Commitments—Cultural Heritage

Title	Objective	Relevance to the Project
Legislation		
National Trust Act (1972) Cap. 20:03.	Stewardship of historic resources and places of cultural significance.	Governs the management of any building, structure, object, or other manmade or natural feature that is of historic or national cultural significance that could be impacted by the Project. Includes shipwrecks and other marine features. Would also apply to the Project in the event of a chance find, in which case the act would require EEPGL to work cooperatively with the National Trust of Guyana to manage any resources discovered.
Maritime Zones Act (2010) Cap. 63:01.	Incorporates certain provisions of the United Nations Convention on the Law of the Sea and the United Nations Educational, Scientific and Cultural Organization Convention on the Protection of the Underwater Cultural Heritage,	Relevant to the Project as it provides for rights and regulation of various maritime zones, including the territorial sea, and the discharge of harmful substances and hazardous waste, as physical movements and/or

Title	Objective	Relevance to the Project
	to provide for marine scientific research, maritime cultural area, eco-tourism, marine parks and reserves, the protection and preservation of the marine environment and for related matters.	changes in water quality or ecological conditions could affect underwater and/or coastal cultural heritage.
International Agreements Signed / Acceded by Guyana		
United Nations Educational, Scientific and Cultural Organization Convention on the Protection of the Underwater Cultural Heritage (2001) (Guyana ratified in 2014)	Protects "all traces of human existence having a cultural, historical, or archaeological character" that have been underwater for over 100 years.	Would apply to any shipwrecks or other submerged cultural heritage in the Project AOI.

8.7.2. Existing Conditions—Cultural Heritage

8.7.2.1. Underwater Cultural Heritage

No previous cultural surveys were undertaken within the vicinity of the PDA prior to EEPGL's activities in the Stabroek Block. From 2016 to 2020, EEPGL commissioned several geophysical and remote sensing surveys of the seafloor within the Stabroek Block, and in 2020, Guardian Geomatics, on behalf of Ocean Infinity, prepared a report on such a survey of the seafloor within the SE Stabroek Block (Guardian 2020). This survey encompassed the Yellowtail Subsea PDA and the data from the survey are therefore relevant for the purpose of the Project. One of the objectives of the study was to identify the occurrence of any potential cultural resources that may impact, or be impacted by, the design and placement of planned subsea equipment within the survey area. Submerged archaeological sites are not expected in waters deeper than approximately 125 meters (approximately 410 feet), which was the approximate sea level during the Last Glacial Maximum (20,000 years before present). Since all Project components with the potential to disturb the seafloor will be deeper than approximately 125 meters (approximately 410 feet), the only cultural resources with a reasonable potential to be present in the Project area are human-made objects that have sunk, most notably shipwrecks.

Remote sensing surveys employ various instruments that use high and/or low frequency sound waves to collect information from the seafloor. The 2020 Guardian survey used several of these including the following:

- Multi-beam echo sounders (MBES), which collect bathymetric data via a wide band of high-frequency sound waves and can detect abnormal shapes (which could potentially include objects of cultural interest) against the surrounding landscape (the MBES model used was Kongsberg EM2040 mounted on an autonomous underwater vehicle [AUV]);
- Side-scan sonars (SSS), which employ high frequency sound waves to collect textural data from the seafloor and provide high resolution images of objects on the seafloor surface (the SSS model used was EdgeTech 2205 mounted on AUV); and

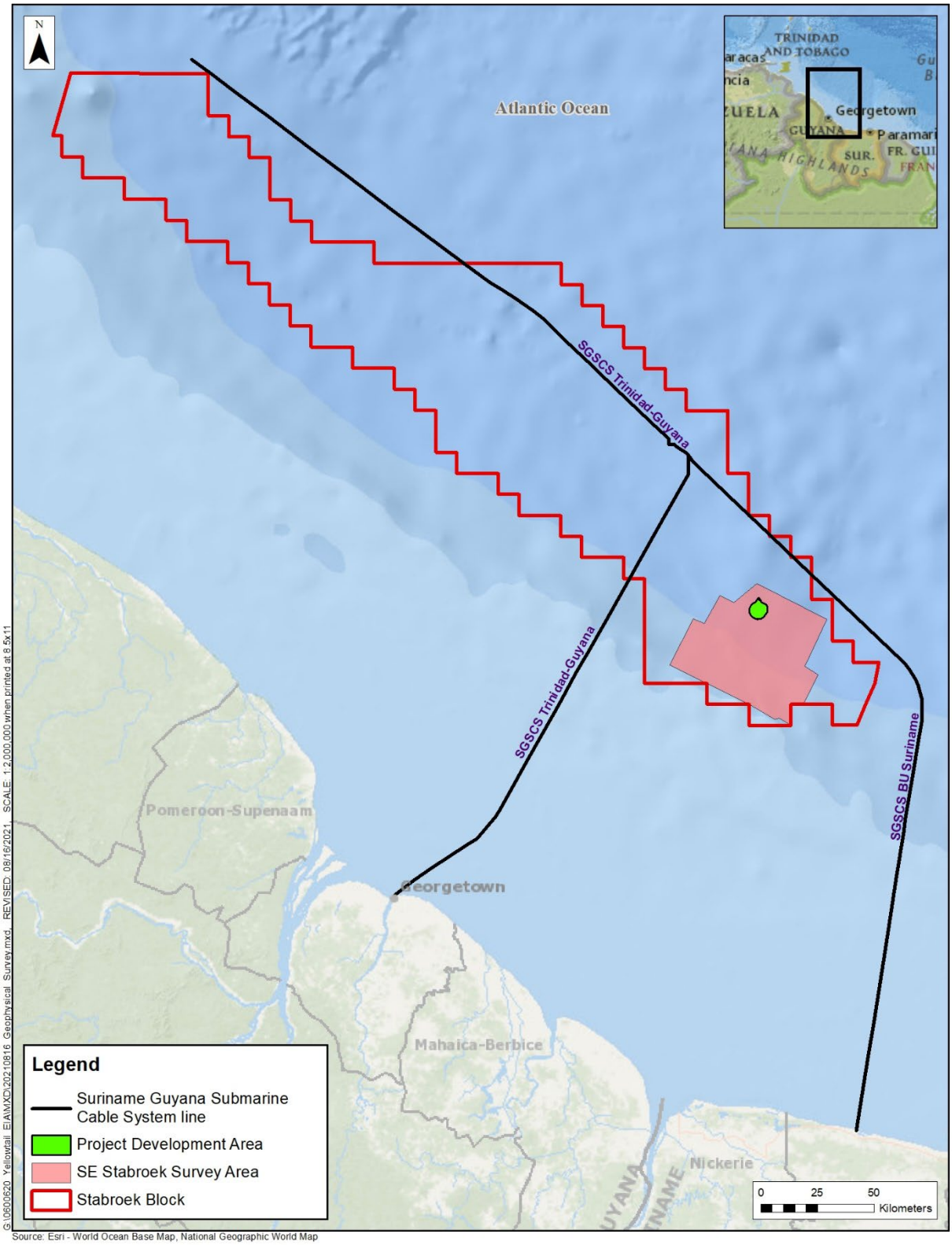
- Sub-bottom profilers, which collect data on subsurface sediments and objects located beneath the seafloor via low frequency sound waves and are capable of locating buried shipwrecks beneath the seafloor surface (the model used was EdgeTech DW-216 mounted on AUV).

The AUV survey was conducted in the SE Stabroek Block, which encompassed the Yellowtail PDA, which in turn is located approximately 203 kilometers (126 miles) northeast of the coastline of Georgetown on the continental slope. The total AUV survey coverage was approximately 2,520 km^2 (973 mi^2) in extent, and the survey was completed over 146 AUV missions. The survey area is shown on Figure 8.7-1 (see area labeled as the "SE Stabroek Survey Area."

The Consultants assessed Guardian's remote sensing survey methodology, including the remote sensing equipment and instrument settings employed and the results produced, according to internationally recognized standards. The Consultants found that the methods used by Guardian and the results yielded by their survey are sufficient to provide existing cultural heritage data for the area of potential impact, as the methodology and quality of data produced met the guidelines and requirements for nearshore and offshore remote sensing cultural surveys as defined by the U.S. Bureau of Ocean Energy Management and Historic England. Together, these guidelines help frame "internationally recognized practices" for remote sensing surveys designed to locate and assess cultural heritage (BOEM 2017; Historic England 2013).

Within the SE Stabroek Survey Area, the SSS survey identified 474 sonar contacts of an anthropogenic nature. These contacts were identified as follows:

- A large shipwreck;
- 170 individual unidentified pieces of debris associated with the wreck, all located to the northeast of the main body;
- 203 point targets (interpreted to consist primarily of unidentified debris, unknown objects, and geological features);
- 93 linear SSS and MBES targets that were interpreted to be unidentified debris, the exception being an abandoned telegraph cable that trends across much of the survey area; and
- Seven wellheads.



Source: Guardian 2020

Figure 8.7-1: Geophysical Survey in the SE Stabroek Block

The shipwreck was estimated to have approximate dimensions of 107 meters (351 feet) long, 23 meters (75 feet) wide, and 7 meters (23 feet) high, located in a water depth of approximately 1,224 meters (4,016 feet) (see Figure 8.7-2). Although the wreck appears to be a contemporary vessel, an accurate date for the vessel is not available; therefore, the wreck and its associated debris are classified as a potentially culturally significant resource, relevant to the history of the region. However, the site is located approximately 24.6 kilometers (15.3 miles) from the Yellowtail PDA, and will be unaffected by the Project's activities. After reviewing the SSS imagery and data collected, the Consultants concluded that some of the 296 remaining SSS contacts, excluding the seven known wellheads, may be located within the Subsea PDA. However, all of these contacts appear likely to consist of anthropogenic debris that includes fishing nets, and chain or cable coils that are of no significant cultural value, as well as geological features and anomalies resulting from naturally occurring submarine landslide events off the continental shelf. As such, the data indicates that no culturally significant resources will be affected by the Project's activities.

Figure 8.7-2: AUV Photograph of Shipwreck

Similar to findings in prior AUV surveys, a linear feature that was interpreted to be an abandoned subsea cable was mapped across the SE Stabroek Survey Area. With respect to cultural heritage, the subsea cable does not have any cultural significance.

8.7.2.2. Coastal Cultural Heritage

Data obtained from the National Trust of Guyana indicate that there are approximately 136 heritage sites in Georgetown comprising monuments, public buildings, schools, gardens, places of worship, and markets among others (EMC Personal Communication 6). There have been no new additions to the cultural sites list in 2020 or 2021 (ERM Personal Communication 30). There are several archaeological sites along the Guyana coast, including shell mounds, seashell deposits, quarries, pollen sections, tool/implements, and ceramic/pottery sites (i.e., scatters) as shown in Table 8.7-2 (EMC Personal Communication 6). These sites are of significant cultural value to both the people of Guyana and researchers, as they offer insight into

the material culture of Indigenous Peoples inhabiting the land before, during, and after contact with Europeans. However, only two of the ceramic/pottery sites on the maps are shown to be located near the shoreline.

Table 8.7-2: Archaeological Sites on the Guyana Coast

Region	Number of Sites	Type of Sites
1	68	Shell Mounds, Seashell Deposits, Ceramics, Tools/Implements, Quarries
2	12	Shell Mounds, Ceramics
3	5	Ceramics
4	17	Ceramics, Shell Mounds, Pollen Sections
5	13	Ceramics
6	21	Ceramics, Pollen Sections, Petroglyphs

As part of the late 2017 and early 2018 Ecosystem Services engagement fieldwork by the Consultants, coastal communities from Regions 1 through 6 were engaged about known archeological sites as well as any locations of cultural significance to each community (e.g., Hindu prayer flag locations, burial and cremation sites). In addition, in the Amerindian coastal communities in Regions 1 and 2, community members were asked about intangible forms of culture heritage along the coast (e.g., cultural knowledge, innovations, and practices of embodying traditional lifestyles). In addition, data obtained from the National Trust of Guyana includes information regarding archaeological sites in the Amerindian coastal communities in Regions 1 and 2. The information on cultural heritage related to this engagement are discussed in Section 8.9.2, Existing Conditions—Ecosystem Services.

8.7.3. Impact Assessment—Cultural Heritage

8.7.3.1. Relevant Project Activities

Offshore Activities

Planned Project drilling and FPSO/SURF installation activities that have the potential to adversely impact cultural heritage located on or beneath the seafloor include the drilling of development wells, the installation of FPSO anchoring structures, and the installation of SURF components.

Onshore Activities

Planned Project activities do not require ground-disturbance in onshore areas. Onshore logistical support will involve use of Guyana port facilities, warehouses, pipe yards, and waste management facilities (e.g., landfills). Use of existing non-Project dedicated facilities will not impact any archaeological sites, as these lands have already been disturbed and therefore are unlikely to contain intact archaeological sites.

According to personnel from the National Trust of Guyana, they anticipate that the burgeoning oil and gas sector may require an expansion of the built environment in Georgetown (such as a planned new shorebase that may be used to support the Project). This could contribute to

changes in the heritage sites located in Georgetown and may result in a loss of heritage including intangible aspects of heritage such as craftsmanship and connection to national identity. Consequently, if this should occur, the current system for managing preservation of historic heritage sites will have to be reconsidered to balance the expansion of the built environment with the protection of heritage sites (ERM/EMC Personal Communication 2).

Although not planned as part of the Project, the construction/expansion of shorebase or other onshore facilities by other entities could therefore disturb new onshore areas, and consequently impact terrestrial (coastal) cultural heritage. However, these works would be performed by the owners/operators of such facilities under separate cultural heritage assessment and approvals processes (where relevant), and are thus outside of the scope of this EIA.

In summary, planned Project activities will not impact any terrestrial cultural heritage resources, and the impact assessment in this section thus focuses on potential impacts on marine cultural heritage. Potential impacts on terrestrial (coastal) cultural heritage resources from unplanned events (i.e., an oil spill) are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

Table 8.7-3 summarizes the Project stages and activities that could result in potential Project impacts on marine cultural heritage.

Table 8.7-3: Summary of Relevant Project Activities and Potential Key Impacts—Cultural Heritage

Stage	Project Activity	Key Potential Impact
Development Well Drilling	Drilling of development wells	Damage to shipwrecks or submerged archaeological sites (if present)
FPSO and SURF Mobilization, Installation, and Hook-up	Installation of FPSO anchoring structures	
	Installation of SURF components	

8.7.3.2. Magnitude of Impact—Cultural Heritage

The assessment of the Project's magnitude of potential impacts on cultural heritage in the Project AOI is determined based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on cultural heritage is defined according to the definitions provided in Table 8.7-4. The following paragraphs discuss the characteristics of each of the potential impacts assessed and the resultant magnitude ratings. These are summarized in Table 8.7-5.

Table 8.7-4: Definitions for Intensity Ratings for Potential Impacts on Cultural Heritage

Criterion	Definition
Intensity	Negligible: No discernible change in the physical condition, setting, or accessibility of sites.
	Low: A small part of a site is lost or damaged, resulting in a loss of scientific or cultural value; setting undergoes temporary or permanent change that has limited impact on the site's perceived value to stakeholders; stakeholder/public or scientific access to the site is temporarily impeded.
	Medium: A significant portion of a site is lost or damaged, resulting in a loss of scientific value; setting undergoes permanent change that permanently diminishes the site's perceived value to stakeholders; site become inaccessible for the life of the Project (at least 20 years) to stakeholders, including traditional users or researchers.
	High: Entire site is damaged or lost, resulting in a nearly complete or complete loss of scientific or cultural value; setting is sufficiently impacted to cause the site to lose all, or nearly all, cultural value or functionality; site becomes permanently inaccessible to stakeholders, including traditional users or researchers.

Marine Cultural Heritage Resources

Based on the geophysical survey described above, there are no identified underwater cultural heritage features that will be impacted by the Project. The identified shipwreck is located well outside of the Yellowtail PDA. However, previously unrecorded cultural remains, or "chance finds," could be encountered and impacted during Project drilling and installation activities. Underwater chance finds could include shipwrecks and associated artifact scatters that were not identified during the geophysical survey. It is conservatively assumed that the intensity of impact on a previously unidentified cultural resource could be as high as **Medium** if seabed-disturbing activities took place in the location of such a resource. If this were to occur, and depending upon the Project stage, the Project would most likely relocate the FPSO anchoring, SURF components, or precise drilling location (up to a few meters) to the extent practicable.

Considering the information presented above, potential impacts related to marine cultural heritage resources, if any, would be limited to the **Direct AOI**. If the resource could not be avoided, any disturbance to marine cultural heritage as a result of Project activities would have a **Long-term** duration. The frequency would be only occasional (if ever), yielding a frequency designation of **Episodic**. This yields a magnitude rating of **Small** for potential impacts on marine cultural heritage resources.

Table 8.7-6: Magnitude of Impact—Marine Cultural Heritage Resources

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
Development Well Drilling SURF/FPSO Mobilization, Installation, and Hook-up	Marine cultural heritage—damage from Project activities disturbing the seabed	Direct AOI	Medium	Episodic	Long-term	Small
	Marine cultural heritage—damage from Project activities disturbing the seabed	Direct AOI	Medium	Episodic	Long-term	Small

8.7.3.3. Sensitivity/Importance of Resource

The resource sensitivity/importance ratings for cultural heritage are defined in Table 8.7-6.

Table 8.7-6: Definitions for Sensitivity/Importance Ratings for Potential Impacts on Cultural Heritage

Criterion	Definition
Sensitivity	Low: Site is not specifically protected under local, national, or international laws or treaties; site can be moved to another location or replaced by a similar site, or is of a type that is common in surrounding region; site has limited or no cultural value to local, national, or international stakeholders; and/or site has limited scientific value or similar information can be obtained at numerous sites.
	Medium: Site is specifically or generally protected by local or national laws, but laws allow for mitigated impacts; site can be moved or replaced, or data and artifacts recovered in consultation with stakeholders; site has considerable cultural value for local and/or national stakeholders; and/or site has substantial scientific value but similar information can be obtained at a limited number of other sites.
	High: Site is protected by local, national, and international laws or treaties; site cannot be moved or replaced without major loss of cultural value; legal status specifically prohibits direct impacts or encroachment on site and/or protection zone; site has substantial value to local, national, and international stakeholders; and/or site has exceptional scientific value and similar site types are rare or non-existent.

Depending on the nature of the specific resources encountered, shipwrecks and/or submerged archaeological sites could be specifically protected by national laws such as Guyana's National Trust Act of 1972, or international conventions such as the 2001 United Nations Educational, Scientific and Cultural Organization Convention on the Protection of the Underwater Cultural Heritage and could possess research and cultural value. For the purpose of this assessment, it was assumed that an as-of-yet unidentified cultural resource could have a sensitivity rating as high as **Medium**.

8.7.3.4. Impact Significance

Based on the magnitude of impact and the receptor sensitivity ratings, the significance of potential cultural resource impacts during the Drilling or FPSO/SURF Installation stages is rated as **Minor**.

8.7.4. Management Measures—Cultural Heritage

As discussed in Section 8.7.2, Existing Conditions—Cultural Heritage, the planned seabed disturbance area for the Project has been subjected to a geophysical survey to assess the presence of any marine cultural heritage. After reviewing the survey data collected, the Consultants concluded that no resources of significant cultural value appear to be present within the planned seabed disturbance area. This has increased the level of certainty that planned Project activities will not disturb significant cultural heritage.

Nevertheless, as part of the ESMP developed in conjunction with the EIA, EEPGL will adopt a Chance Finds Procedure (approved by National Trust of Guyana; ERM/EMC Personal Communication 1), which requires temporary cessation of Project activities in the event of a

chance find of a cultural heritage resource, assessment of the chance find by a cultural heritage specialist, and development of a treatment plan for significant chance finds in consultation with the National Trust of Guyana and other cultural heritage stakeholders, as appropriate. The Chance Finds Procedure also addresses monitoring and training requirements.

Considering the implementation of the measures outlined in the Chance Finds Procedure, the magnitude of the impact would be expected to be reduced to **Negligible**, as activities would be adjusted/curtailed upon discovery of a previously unidentified cultural resource. This would reduce the residual impact significance rating to **Negligible**.

Table 8.7-7 summarizes the mitigation and monitoring measures relevant to this receptor.

Table 8.7-7: List of Mitigation and Monitoring Measures

Mitigation Measures
Adopt and implement as needed a Chance Find Procedure that describes the requirements in the event of a potential chance find of heritage or cultural resources.
EEPGL will train Project and contractor personnel with the potential to identify underwater chance finds, so that these operators are informed about the identification of chance finds, appropriate use of the Chance Find Procedure, and monitoring and reporting requirements.
Monitoring Measures
EEPGL's cultural heritage monitoring program will apply to all activities that disturb the sea floor, to identify, record, and protect cultural heritage that was not identified during pre-drilling or pre-installation cultural heritage investigations. Monitoring will be conducted by Project staff and remotely supported by an on-call professional cultural heritage specialist.

Table 8.7-8 summarizes the assessment of potential pre-mitigation and residual Project impacts on cultural heritage. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the cultural heritage-specific methodology described in Sections 8.7.3.1 and 8.7.3.2.

Table 8.7-8: Summary of Pre-Mitigation and Residual Impacts—Cultural Heritage

Stage	Resource/Receptor Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Well Drilling	Marine cultural heritage—damage from Project activities disturbing the seabed	Low	Medium	Minor	Implement Chance Finds Procedure as needed	Negligible
FPSO and SURF Mobilization, Installation, and Hook-up	Marine cultural heritage—damage from Project activities disturbing the seabed	Low	Medium	Minor	Implement Chance Finds Procedure as needed	Negligible

8.8. LAND USE

8.8.1. Administrative Framework—Land Use

No legislation, policies, or treaty commitments are specifically and directly relevant to the assessment of potential impacts on land use for the Project. The Project will not directly change existing land uses. Any induced land use changes would need to comply with applicable requirements.

8.8.2. Existing Conditions—Land Use

Guyana is bordered by Suriname to the east, Venezuela to the west, and Brazil to the southwest. Its 215,000 km^2 (83,012 mi^2) of territory can be broadly divided into four regions (see Figure 7.2-1, Guyana's Ecoregions):

- The coastal plain stretches 440 kilometers (273 miles) from the Corentyne River in the east to Waini Point in the west and ranges from approximately 5 to 65 kilometers (approximately 3 to 40 miles) wide along the coast. It accounts for less than 8 percent of the country's land area and is approximately 1.4 meters (4.6 feet) below mean high tide level.
- The hilly sand region is a largely vegetated zone dominated by white, sandy soils and undulating terrain lying inland from the coastal zone. This zone ranges from approximately 150 to 250 kilometers (approximately 93 to 155 miles) wide, is largely forested, and contains most of the country's mineral deposits.
- The interior highlands, extending from the hilly sand region to the country's southern borders, is part of the pre-Cambrian Guiana Shield, and also contains mineral deposits. This zone makes up the largest land area in the country.
- The interior savannas consist of two main savanna complexes: the Rupununi Savannas and the Intermediate Savannas. The Rupununi Savannas cover 15,540 km^2 (6,000 mi^2) and lie in the southwestern part of the country. The Intermediate Savannas cover more than 5,180 km^2 (2,000 mi^2) and lie 97 kilometers (60 miles) from the mouth of the Berbice River.

As described above, Guyana is a sparsely populated country, with the majority of the population and physical developments concentrated in the coastal plain region. This region has two wet and two dry seasons, and as a result is the main agricultural region of the country. This region is below sea level and is vulnerable to both inundation from the sea as well as intense rainfall runoff. The coastal areas are mostly protected by mangrove forests and manmade concrete and earthen dykes.

In 2018, the area considered as agricultural lands as a percentage of the total land area in Guyana was reported to be 6.4 percent (World Bank 2021). Most of the cultivated land is also concentrated in the coastal plain, where the majority of the population resides (FAO 2015).

Figure 8.8-1 shows land use patterns on the coastal and hilly sand areas. In the coastal plain areas, agriculture is dominant in Regions 2, 3, 4, 5, and 6 and occurs to a lesser extent in Region 1. The main crops are sugar, rice, and coconut plantations, interspersed with smaller-

scale establishments of cash crops, non-traditional crops, and livestock. In the hilly sand region, the predominant land use is forestry and mining.

The SBPA is a notable feature in the coastal area of Region 1. It was designated a Protected Area with the passage of the Protected Areas Act of 2011, and is the only Protected Area on Guyana's coast. In addition, the Forests Act of 2009 protects mangrove forests along the coastline and in inland areas. More information on the SBPA and coastal mangrove forests is provided in Section 7.2.2, Existing Conditions—Coastal Habitats.

According to the Guyana Lands and Surveys Commission (GLSC), the oil and gas sector has directly influenced demand for land and has increased the value of land, specifically in Region 4. GLSC representatives claim that since the first discovery of oil was announced in 2015, demand from local and international investors for private and public lands has increased in Region 4, and with every new discovery, there are increased expressions of interest from international investors for public land. The GLSC is considering expanding the state land area available for lease; however, there is limited available land suitable for this purpose. Demand for state land outside Region 4 has also increased but not as dramatically (ERM/EMC Personal Communication 8).

Several stakeholders have also shared their expectation that land use in Region 4 and other coastal regions is likely to continue to change as the oil and gas sector develops. In particular, the socioeconomic benefits of the oil and gas sector (including generation of direct, indirect, and induced employment and income) may increase demand for housing, and more state lands are likely to be allocated as residential areas. There may also be a potential need for land for new shorebases, other oil and gas-associated businesses and activities, and accommodation facilities such as guesthouses and hotels in coastal areas. It is also expected that agricultural lands may be converted to residential or commercial uses in coastal regions, therefore changing land use and potentially losing agricultural capacity.

Personnel from the GLSC also highlighted the importance of integrated land use planning involving the collaboration of various government agencies to forecast how demand for land is likely to evolve as a result of the oil and gas sector, and to facilitate informed decision making on leasing land. Guyana has a National Land Use Plan (GLSC 2013) that guides the GLSC in land management and administration. The GLSC plans to revise this plan to include oil and gas sector considerations and is currently implementing a *Mainstreaming Sustainable Land Development and Management* project (FAO and GLSC 2017), which will strengthen institutional and human capacities for participatory and integrated land use planning (ERM/EMC Personal Communications 6 and 8).

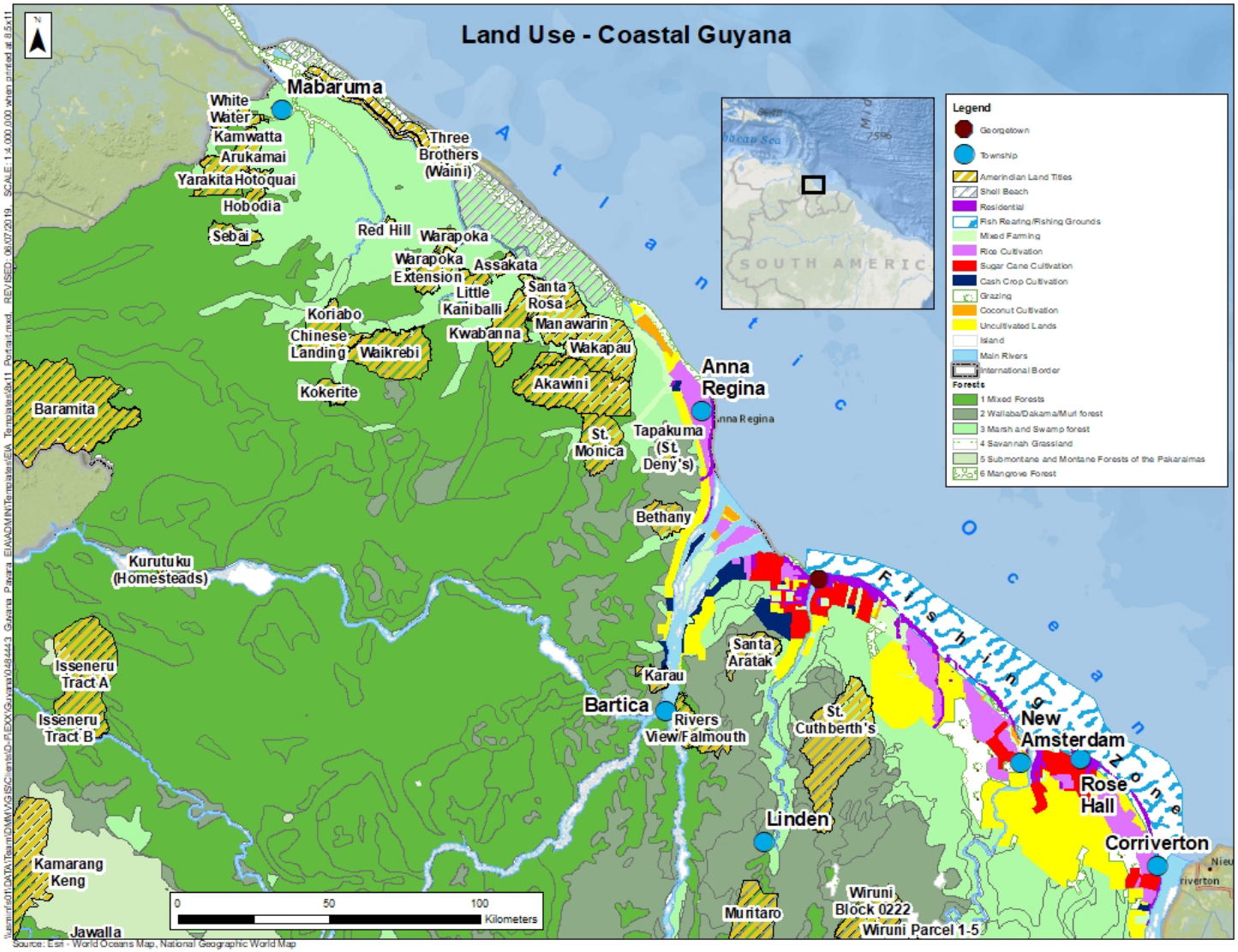


Figure 8.8-1: Land Use and Land Cover in Coastal Guyana

8.8.2.1. Land Ownership

There are three types of land tenure in Guyana: public land, private land, and Amerindian land. Public land includes state land and government land (land owned by individual government entities). Public land accounts for an estimated 76 to 85 percent of all land; Amerindian land held under communal title accounts for approximately 14 percent; and up to 10 percent of land is privately held[30] (GLSC 2013; FAO and GLSC 2017; IDB 2010). Amerindian lands are owned collectively and are not subject to transfer or sale.

On the coastal plain, most of the cultivated lands are held as sugar estates under the Guyana Sugar Corporation or as rice plots. The sugar lands consist of both freehold (lands owned privately) and leasehold (lands leased by the state) tenure. Most rice lands under 6 hectares (15 acres) have been converted to freehold tenure, while the larger plots are under leasehold, administered by the GLSC or other designated authorities (FAO and GLSC 2017). With the forest and mineral resources owned by the state, tenure in these sectors is in the form of limited term concessions from the Guyana Forestry Commission and the Guyana Geology and Mines Commission, respectively.

Leases of government-owned lands are issued by the GLSC or other designated authorities. Freehold titles are recorded by two separate agencies: the Deeds and Commercial Registries Authority and the Land Registry. The Deeds and Commercial Registries Authority is responsible for administering the laws enacted by Parliament affecting land (DCRA undated). The Land Registry was established to simplify land registration and provide security of tenure to owners of titled public lands (Land Registry undated).

According to a study of the land registration system in Guyana conducted by the IDB, the country's dual property registration systems (title registration and deed registration) have regulations that overlap and conflict, and are considered complex and bureaucratic. The systems are also considered ineffective in managing and enforcing rights. As a result, a large number of land owners do not register their properties or do not keep their ownership rights up to date (IDB 2010). However, in recent years, the capacities of the Deeds and Commercial Registries Authority and Land Registry have improved to enable better execution of their legal mandates. In addition, the GLSC is continuously working to regulate land to provide security of tenure on public lands.

Land ownership in Guyana, particularly in hinterland regions, is guided by the government's policy on multiple uses of land, which seeks to harmonize surface and sub-surface uses of land. In 2013, approximately 95 percent of all mining leases were within the state forest estate and on lands that have been leased by the Guyana Forestry Commission (GLSC 2013). Under a policy of multiple uses of land, lessees who have surface rights are given priority access to the land.

[30] This breakdown of public, private, and Amerindian land is not well documented. In particular, the area of private land is unknown, and may be as low as 1 to 2 percent of total land area. In regard to Amerindian land, the estimated 14 percent excludes areas under dispute or awaiting demarcation (GLSC 2013).

8.8.3. Impact Assessment—Land Use

This section assesses potential Project impacts on land use and ownership. The key potential impacts considered are conversion of land from one use to another, and change of land ownership type (i.e., change between public, private, and Amerindian ownership). Potential impacts on housing and accommodation demand as a direct result of the Project are covered in Section 8.5, Social Infrastructure and Services.

8.8.3.1. Relevant Project Activities and Potential Impacts

The majority of Project activities will occur offshore. Most of the major SURF and FPSO equipment for the Project will be preassembled, pretested, and shipped directly to the Yellowtail PDA from points of origin outside Guyana, although some will be pre-assembled in-country. Some equipment, supplies, and materials may be temporarily staged at shorebases, laydown yards, and warehouses in Guyana until transferred offshore for installation or use by the Project. There are plans for development of new third-party operated shorebase facilities, where SURF equipment for EEPGL's development projects could be assembled prior to transfer offshore for installation. Depending on the schedule for their completion, a new facility may be used by the Project, by other EEPGL projects, or by other oil and gas operators in Guyana.

The above-referenced onshore facilities will not be owned or operated by EEPGL. If the owners/operators of such facilities find it necessary to expand their existing operations onto adjacent land or to develop their facilities in separate, new areas, potential land use impacts and environmental authorizations associated with these expansions will be addressed by the owners/operators of such facilities, and would be out of the scope of this EIA. EEPGL's new office facility, to be located at Ogle in Region 4, is covered under a separate environmental authorization. In summary, there are no plans for EEPGL to develop additional parcels of land as part of the Project.

Table 8.8-1 summarizes the Project stages and activities that could result in potential Project impacts on land use, as well as the receptors that could potentially experience these impacts.

Table 8.8-1: Summary of Relevant Project Activities and Key Potential Impacts—Land Use

Stage	Receptor(s)	Project Activity	Key Potential Impacts
All Project stages	Current owner(s) and/or user(s) of land in Georgetown	Use of land for onshore Project-related activities	Conversion of land from other use(s) Change of land ownership

8.8.3.2. Magnitude of Impact—Land Use

The assessment of the Project's magnitude of potential impacts on land use is based on consideration of geographic extent, frequency, duration, and intensity. The intensity of potential impacts on land use is defined in Table 8.8-2.

Table 8.8-2: Definitions for Intensity Ratings for Potential Impacts on Land Use

Criterion	Definition
Intensity	Negligible: No significant changes in land use type or ownership type.
	Low: Land use change occurs for one or multiple parcels, but consists of change to a land use type similar to the current use (e.g., change from one type of industrial activity to another or from commercial to industrial). No changes occur in ownership type (i.e., public, Amerindian, or private ownership).
	Medium: Land use changes occur for multiple land parcels or tracts and may consist of changes to land use type (e.g., substantial clearing of forest or other vegetation, loss of residential units). Changes to ownership type (i.e., public, Amerindian, or private ownership) do not occur.
	High: Land use changes occur for large areas of land and may consist of changes to land use type (e.g., substantial clearing of forest or other vegetation, loss of residential units). Changes may occur to ownership type.

The Project will require the use of onshore storage facilities and laydown areas in Guyana for Project materials (e.g., drilling fluid, pipe joints) and may also use onshore facilities in Guyana for pre-fabrication or assembly of Project equipment. At this time, EEPGL plans to use existing Guyana shorebases to support the Project; new onshore facilities in Guyana may also be used by the Project (these would be developed by third parties as separate projects). Similarly, EEPGL is planning to use existing third-party EPA-permitted waste management facilities in Guyana; additional Guyanese or regional waste management services may also be used in the future (these would be developed by third parties as separate projects).

No land use conversions or land ownership changes are planned by EEPGL as a part of the Project. While there may be some land use conversions and/or land ownership changes associated with third parties converting or expanding existing facilities or developing new facilities to serve the needs of the Project and/or other oil and gas operations, these actions will be addressed by separate environmental authorizations processes. Accordingly, the intensity of Project-related land use conversions or land ownership changes is rated as **Negligible** (see Table 8.8-3).

Table 8.8-3: Magnitude of Impact—Land Use

Stage	Receptor—Impact	Geographic Extent	Intensity	Frequency	Duration	Magnitude Rating
All Project stages	Current owner(s) and/or user(s) of land in Georgetown—land conversion of land use or change in land ownership	NA	Negligible	NA	NA	Negligible

NA = not applicable

8.8.3.3. Sensitivity of Receptors—Land Use

If the Project were intending to convert land use or change land ownership, receptors for this potential impact would be the current owner(s) of the land to be converted by the Project, as

well as the current user(s) or beneficiaries of such land, if any. In this case, the receptor sensitivity ratings for land use would be determined as defined in Table 8.8-4.

Table 8.8-4: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Land Use

Criterion	Definition
Sensitivity	Low: Receptor(s) do not currently reside on the land or make use of it for subsistence or primary livelihood activities or recreation.
	Medium: Receptor(s) do not currently reside on the land or make use of it for subsistence but may rely on it for income generation or recreation.
	High: Receptor(s) currently reside on the land and/or use it for subsistence, or for their primary/sole means of livelihood.

At this time, EEPGL does not intend to convert land use or change land ownership as part of the Project, so no receptor sensitivity rating applies. Any changes in land use by third parties to serve the needs of the Project and/or other oil and gas operations will be addressed by separate environmental authorization processes.

8.8.3.4. Impact Significance—Land Use

Based on the magnitude of potential impact (irrespective of a potential receptor sensitivity rating), the significance of potential land use impacts is rated as **Negligible**.

8.8.4. Management Measures—Land Use

Table 8.8-5 summarizes the assessment of potential pre-mitigation and residual Project impacts on land use. The significance of potential impacts was assessed based on the impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the land use-specific methodology described in Section 8.8.3.2. The development of impact-specific mitigation measures has focused on impacts with a predicted significance of minor or higher. Impacts with a negligible significance were not prioritized for mitigation. Given the **Negligible** significance rating, no mitigation measures are proposed for potential impacts to land use.

Table 8.8-5: Summary of Potential Pre-Mitigation and Residual Impacts—Land Use

Stage	Resource/ Receptor Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	Current owner(s) or user(s) of land—conversion of land use or change in land ownership	Negligible	NA	Negligible	None	Negligible

NA = not applicable

8.9. ECOSYSTEM SERVICES

Ecosystem services are typically defined as the benefits that people obtain from the natural environment, including natural resources that underpin basic human health and survival needs, support economic activities, and provide cultural fulfilment. Ecosystem services are categorized as provisioning, regulating, cultural, and supporting services, as defined below (Millennium Ecosystem Assessment 2005):

- Provisioning services: goods or products obtained from ecosystems such as food, fresh water, timber, fiber, and other goods;
- Regulating services: benefits obtained from an ecosystem's control of natural processes such as climate, carbon storage, waste absorption, water flow, disease regulation, pollination, and protection from natural hazards;
- Cultural services: non-material benefits obtained from ecosystems such as recreation, spiritual values, and aesthetic enjoyment; and
- Supporting services: natural processes such as erosion control, soil formation, nutrient cycling, and primary productivity that maintain other services.

The implementation of an ecosystem services approach played an important role in guiding other sections of the EIA. The ecosystem services screening process[31] informed the services and types of information that were incorporated into the other existing conditions and impact assessment studies and sections (e.g., coastal habitats, ecological balance and ecosystems, employment, and livelihoods).

8.9.1. Administrative Framework—Ecosystem Services

Table 8.9-1 summarizes the legislation, policies, or treaty commitments that are specifically relevant to the assessment of potential impacts on ecosystem services.

Table 8.9-1: Legislation, Policies, or Treaty Commitments—Ecosystem Services

Title	Objective	Relevance to the Project
Legislation		
Forests Act (2009) Act. No. 6 of 2009	Consolidates the law relating to forests and makes provisions for sustainable forest management and forest conservation.	Covers mangroves, which are classified as a forest type and subject to protection measures under the Act. Mangrove ecosystem makes up a significant portion of Guyana's coastal zone, and could potentially be affected

[31] A screening exercise was undertaken with community stakeholders to identify a comprehensive list of the ecosystem services that are potentially present along coastal communities in Regions 1 through 6. This step does not attempt to consider the importance of the services to beneficiaries or the likelihood of the Project impacting them in the event of an unplanned oil spill; it simply asks whether a service is likely to be present or not in each coastal area. For a service to be considered present, it must meet two criteria: (1) habitats present in the Study Area are believed to provide this service or are similar to habitats elsewhere that provide this service; and (2) people are believed to benefit from the service, either at the local, national, or global level, and/or the Project is expected to benefit from this service.

Title	Objective	Relevance to the Project
		in the unlikely event of an oil spill event which reaches the shore.
Sea Defence Act (1933)	Makes provisions for the construction, maintenance, and protection of sea defenses, which includes manmade structures as well as natural defenses.	Covers the protection of mangroves as a natural sea defense. Relevant to the Project in the unlikely event of an oil spill reaching the shore and causing mangrove damage.
Protected Areas Act (2011)	Provides for the protection and conservation of Guyana's natural heritage and natural capital by the creation, management, and financing of a national system of protected areas; the maintenance of ecosystem services of national and global importance, including of climate regulation; the establishment of a protected areas commission; the establishment and management of a protected areas trust fund; and the fulfilment of Guyana's international environmental responsibilities.	Under this Act, terrestrial and marine protected areas could be established. However, currently there are no known initiatives towards setting up marine protected areas.
International Agreements Signed / Acceded by Guyana		
Convention on Biological Diversity (Guyana signed in 1992 and ratified in 1994)	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Encourages Project design and execution so as to protect and conserve biological diversity.

8.9.2. Existing Conditions—Ecosystem Services

A field team consisting of socioeconomic and biodiversity experts conducted an Ecosystem Services Screening, Scoping, and Assessment exercise involving all 63 coastal NDCs, CDCs, VCs, and TCs in Regions 1 through 6 (see Section 8.1.2.1, Administrative Divisions in Guyana, for a list of the NDCs, CDCs, VCs, and TCs). This information was obtained during the ecosystem services field work completed in Region 1 in April 2018 (ERM/EMC 2018), and validated in communities in 2019. Appendix S, Enhanced Coastal Sensitivity Mapping—Ecosystem Services Final Report, provides all data and analysis associated with this work. Information is also supplemented by information gathered through the participatory fishing study undertaken between January 2019 and March 2020 (Appendix D, Participatory Fishing Study Final Report January 2019–March 2020). Findings related to ecosystem services and the participatory fishing study were subsequently validated and, where relevant, updated through targeted engagement efforts in 2021.

The purpose of the ecosystem services field study was to identify the ecosystem services that are potentially present along the coastline and shore zones in Regions 1 to 6 using Community-based Participatory Research and traditional knowledge. The team interviewed more than 500 community leaders and members about the relationship between people and the environment

along the shore zones, and about the locations of specific ecosystems services. Representatives from the groups of interviewees then aided the team in field-verifying the locations of the services and mapping the information in a geographic information system database. The team used a screening checklist to determine whether a service was likely to be present or not in each coastal or shore zone. For a service to be considered present, it needed to meet two criteria:

- Habitats present in the study area (immediate coastal area throughout Regions 1 through 6, up to a distance of 500 meters [1,640 feet] from the shoreline) are believed to provide the service or are similar to habitats elsewhere that provide the service; and
- People are believed to benefit from the service, either at the local, national, or global level.

Following completion of the screening exercise, the team, including members of the NDC and VCs, along with local community members, used the ecosystem services that were identified as present or potentially present as a guide for the field observations. This scoping step aimed to:

- Establish a list of ecosystem service beneficiaries;
- Establish the value of ecosystem services to beneficiaries;
- Identify and map the habitats and resources that provide ecosystem services in the study area; and
- Identify the existing condition and trends of natural resources providing ecosystem services.

The screening and scoping information provided an ecosystem services baseline, which revealed that the marine and coastal environments in Guyana provide all four of the aforementioned categories of ecosystem services, some of which are critical for the wellbeing and livelihoods of coastal communities. These are described by category and by region below.

In addition to the coastally focused ecosystem services that were the focus of the aforementioned study, there are numerous ecosystem services provided by the offshore marine ecosystem (i.e., the open ocean) that provide benefits to people at local, national, and global scales; these include but are not limited to carbon storage, waste absorption, gene flow, and nutrient cycling. These services are discussed in more detail in Section 7.10, Ecobalance and Ecosystems.

Following the screening, scoping, and assessment exercise, socioeconomic and biodiversity experts returned to 61 of the same 64 coastal NDCs, RDCs, VCs, and TCs in June 2019 to conduct a validation effort of the ecosystem services baseline data collected during the previous assessment phase (the Black Bush Polder NDC in Region 6 was not revisited due to its distance from the coastal zone; Georgetown City data were validated through informal engagement; and Haimokabra and Waramuri in Region 1 were visited simultaneously since Haimokabra is considered a satellite village of and shares leadership with Waramuri). This additional validation step, in which over 500 community leaders and members participated, enhanced the scientific accuracy of the original reporting by allowing stakeholders to review and comment on the results of the screening, scoping, and assessment exercise. Any changes or additions to individual ecosystem services from the exercise were documented and larger

trends that could have occurred over time as a result of specific ecosystem management interventions (e.g., mangrove programs) or extrinsic factors (e.g., population changes) were identified.

8.9.2.1. Provisioning Services

Marine fishing for various species of fish and shellfish is a vital source of protein and income to coastal communities. In coastal areas, especially in Regions 5 and 6, nearshore inland fishing and shrimping is also significant. Agriculture is also prevalent in coastal areas in all regions, including cultivated coconuts, cash crops, and livestock grazing. Some communities in the coastal area (particularly Amerindian communities in Region 1) harvest a range of naturally occurring resources for household use and sale. This includes manicole (heart of palm), mangrove bark and wood, timber, medicinal plants, and crabwood seeds that are processed to make crabwood oil.

In addition, trapping and hunting of local wildlife are also practiced for meat and/or sale of live animals. Throughout the coastal areas, the waterways facilitate transportation and trade, and in some situations are the only means of transportation available, especially in Region 1 and between Regions 2 and 3.

Through Project engagement activities in 2021, the leaders of Region 1 communities reported an increase in crab (especially during the crabbing season), although market disruptions during the pandemic have resulted in less crabbing for commercial purposes and the price of a crate of crabs has declined by 50 percent or more. Fishing and hunting for commercial purposes have also declined due to disruption in markets due to the pandemic.

Community engagement over the last 3 years has revealed that the number of Venezuelans (including those of Warrau origin and other indigenous groups) migrating to Region 1 has increased, particularly in border communities of the Mabaruma sub-region. This includes in-migration throughout the COVID-19 pandemic and in response to violence in Venezuela (Sutherland 2021). For specific Region 1 border communities, estimates of in-migration include 63 persons in Imbotero in 2021 (ERM Personal Communication 33) and—within a short period in January 2021—an estimated 120 persons in Smith Creek, 100 persons in White Water, and 57 persons in Yarkita (Sutherland 2021). With indigenous roots, many of the Venezuelan in-migrants have been harvesting naturally occurring resources to sustain themselves.

Based on the findings of the ecosystem services assessment exercise, provisioning services are the primary service provided by the coastal ecosystem throughout all regions. The most common provisioning services identified include:

- Fish, shrimp, and crabs caught for subsistence or commercial sale;
- Annual and permanent cultivated crops grown for subsistence use and commercial sale;
- Agricultural and grazing, including livestock farming supported by coastal grassland and plants; and
- Animals (including reptiles, birds, and mammals) hunted primarily for food.

8.9.2.2. Cultural Services

Cultural services were the second-most prevalent ecosystem service. The most common cultural services identified include:

- Cultural value placed on traditional practices, such as use of a location for prayer services (primarily in Regions 2 through 6);
- Use of natural spaces and resources for local tourism or local recreation, such as use of coastal walls for walking, coastal parks for relaxing, and beaches for recreational fishing, picnicking, games, etc.; and
- Value placed on the aesthetics provided by landscapes and seascapes.

Throughout Guyana's populated coastal regions in Regions 2 through 6, the seashore is often used in religious Hindu funeral and cleansing ceremonies. The Hindu community in Guyana has a number of crematoriums along the coast, and ashes are disposed in the ocean as part of funeral ceremonies. In addition, prayer and bathing ceremonies are performed informally by members of the Hindu community year-round, but especially during the holy festival of Kartik Snan, which occurs in October or November each year (ERM Personal Communication 11; ERM/EMC 2018). In the Lusignan coastal area in Region 4, the NDC has reported conflicts with the use of the area for religious ceremonies and the disposal of waste, especially animal carcasses. This has led to a movement of religious worshippers to other areas along the coast as far as the Unity foreshore (ERM Personal Communication 35).

In Region 1, the SBPA has high aesthetic and educational value and potential for ecotourism due to its importance as a marine turtle nesting area, even though infrastructure in the area is not well developed and tourism activity is limited. The community of Warapoka in Region 1 has been actively engaged in ecotourism, with visitor counts on the rise over the past several years due in part to government-sponsored ecotourism programs. However, tourism has been significantly reduced across the country since the onset of the COVID-19 pandemic in early 2020, and related travel and social distancing restrictions. During Project engagement in 2021, communities reported a decline in tourism in Region 1, although they noted that this has provided an opportunity for local-level training and tourism product improvements, including small infrastructure projects.

Outside of the pandemic restrictions, the caves, petroglyphs, shell mounds, harpy eagle nesting sites, and other eco-related attractions within the community, as well as sport fishing at Luri Creek, serve as attractions for tourists. Waramuri and Assakata are both actively developing plans to build ecotourism infrastructure and attract funding to enhance ecotourism activities.

8.9.2.3. Regulating Services

Regulating services represented the third-most prevalent ecosystem service identified in the six regions. The most common regulating services identified include:

- Shoreline and riverbank protection and the role of mangroves in protecting crops, buildings, and recreation areas from waves, wind, and flooding; and

- Erosion protection and the role of vegetation in regulating erosion on slopes.

Guyana's coastal plain is vulnerable to coastal flooding due to its low elevation and mangrove forests, with their dense root systems, are an important component of the country's natural and manmade sea defense system. Mangroves also filter sediments, protecting sensitive seagrass beds from being smothered.

8.9.2.4. Supporting Services

Mangrove forests along the coast play an active role in nutrient cycling and act as nurseries for ecologically and commercially important fish and shellfish species. Mangrove and other coastal ecosystems, such as brackish lagoons, brackish herbaceous swamps, and swamp forests, also provide habitat for a diversity of flora and fauna, including those with tourism value and potential, such as migratory shorebirds (WWF 2021).

Supporting services are intermediate ecological outcomes that are not directly used, but rather support other ecosystem services. Supporting services may be under-identified relative to the other categories of ecosystem services because services that are directly used are better understood and more easily identified by stakeholders. Therefore, in the Consultants' professional experience, the relatively low prevalence of identified supporting services across the six regions is not atypical. The service "habitat provision" is an exception, because it is sometimes simultaneously valued as an "end-use" service in addition to its supporting role by stakeholders. In this analysis, stakeholders often valued mangroves for their maintenance of biodiversity (a supporting service) while also valuing their contribution to the resilience of coastal ecosystems and shoreline protection (both regulating services).

Figure 8.9-1 summarizes the distribution of identified ecosystem services across the four ecosystem service categories.

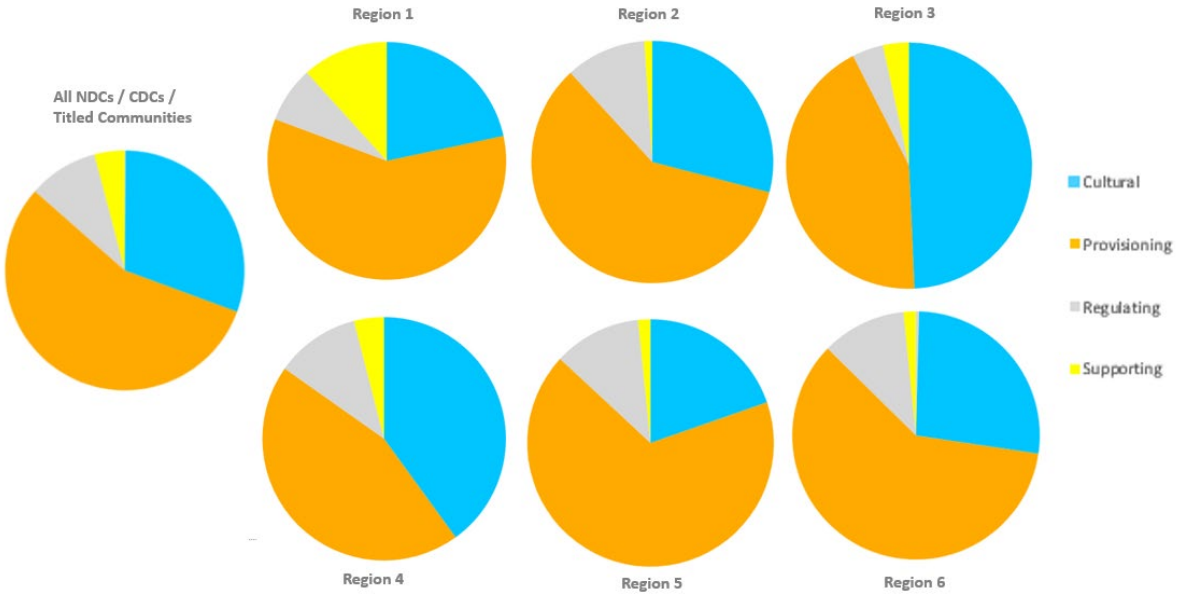


Figure 8.9-1: Distribution of Ecosystem Service Categories

8.9.2.5. Prioritization of Services

After establishing the ecosystem services baseline, the Millennium Ecosystem Assessment 2005 methodology calls for an ecosystem services prioritization. The prioritization process has been designed to be consistent with international best practice using the 2012 International Finance Corporation Performance Standards as guidance (IFC 2012), with the objective of identifying services that are important to local stakeholders and difficult to replace, where loss or degradation of the service could adversely affect local communities. The prioritization process considered the following criteria:

- **Importance of ecosystem services:** Importance to beneficiaries was assessed according to the following criteria and assigned one of four ratings—from *low* to *essential*—based on:
  - Intensity of use (e.g., daily, weekly or seasonal use); quantitative data were used if available and relevant;
  - Scope of use (e.g., household versus community level, commercial use only, subsistence only or both);
  - Degree of dependence (e.g., contribution of fish to total protein in the diet; contribution of fishing to employment in the community); and
  - The importance of the service, as expressed by stakeholders and beneficiaries, including cultural and historical importance.

  Determining the importance rating includes quantitative elements (intensity, scope, and degree); however, the actual importance expressed by stakeholders and beneficiaries takes

precedence over other criteria. For example, if trapping appeared to occur at a location on a monthly basis for subsistence by a few villagers in a community, it may be rated as low based on frequency of the activity. However, if various beneficiaries and stakeholders claimed that trapping was of significant importance to them, the rating would be moderate. Where a service was of greater or lesser importance to different beneficiary groups, two (or more) ratings were assigned so that impacts on these groups could be assessed individually.

- **Availability of alternatives (replaceability):** Understanding the availability of spatial alternatives is critical to assessing the extent to which a community will be adversely impacted if that service declines due to Project activities. The "replaceability" of a service was assessed according to the following criteria and assigned one of three ratings from *high* (many alternatives) to *low* (few or no alternatives):
  - The existence of spatial alternatives, including both natural replacements (e.g., the replacement of one type of wild food with another) and manmade substitutes (e.g., availability of manmade items as an alternative to handicrafts);
  - The accessibility, cost, and sustainability of potential alternatives, including a consideration of other users and the existing status and threats to the resource(s) providing natural alternatives to the service; and
  - Preference/appetite for and cultural appropriateness of alternative services.

After compiling information on the importance and replaceability of each service, these ratings were combined to assign an overall priority rating to the service (see Table 8.9-2). Ecosystem services with *high* or *critical* priority ratings are considered to be "priority" ecosystem services. As noted above, some services may have different importance ratings for different beneficiary groups, and therefore may be rated priority services for some beneficiaries but not for others.

Table 8.9-2: Assigning a Priority Rating to Ecosystem Services

		Replaceability of Service		
		High (many spatial alternatives)	**Moderate** (some spatial alternatives)	**Low or Not Replaceable (few to no spatial alternatives)**
Importance of Service to Beneficiaries	Essential	High	Critical	Critical
	High	Medium	High	Critical
	Moderate	Low	Medium	High
	Low	Low	Low	Medium

Figure 8.9-2 summarizes the distribution of specific ecosystem service types depending upon priority ranking.

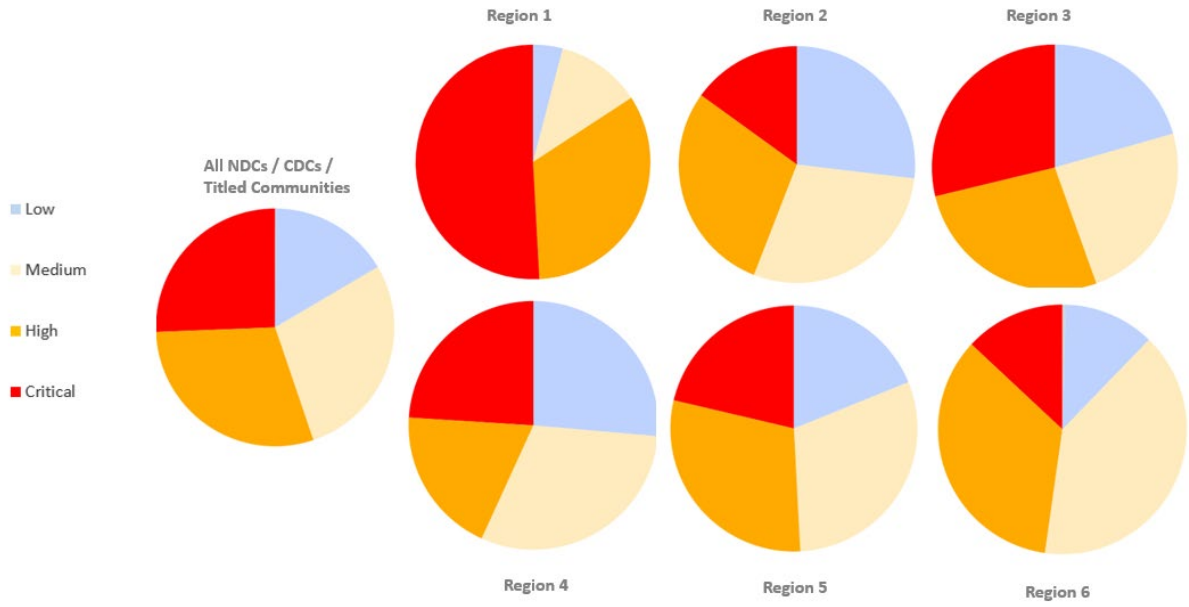


Figure 8.9-2: Distribution of Ecosystem Service Priorities

8.9.2.6. Summary of Findings by Region

As one of the primary goals of the baseline study was to understand the relationship between coastal communities and the natural environment along the entire coast in Regions 1 through 6, the ratings vary depending on the responses from each NDC or VC. For example, in one council in Region 2, livestock farming along the coastal wall was reported to be low priority, whereas in an adjacent council, the same service was considered a critical priority since a larger number of families rely on the livestock and there are no other locations for livestock to graze. Furthermore, some services may have different importance ratings for different beneficiary groups, and therefore may be rated as high priority services for some beneficiaries but not for others.

Figures 8.9-3 to 8.9-10 show how the ecosystem types are depicted in the aforementioned geographic information system database. The figures show the ecosystem service locations, by type, identified by the interviewees during the engagement process and which were mapped during the field observations. They are displayed by ecosystem service (color of symbol) using the methodology described above. Ecosystem service locations that were updated or added to date during the 2019 validation field effort are labeled accordingly. These figures also provide a location of each NDC/RDC/VDC/TC visited during both the 2017–2018 baseline collection field effort and during the 2019 validation field effort to date.

In the case of Region 1, Figure 8.9-4 shows the ecosystem service “general areas,” by type, identified by Region 1 village leaders and villagers during the engagement process. The “general areas” map is provided for Region 1 because some areas identified by village leaders and villagers in Region 1 could not be field-verified (based on limitations to access along the SBPA and Region 1 coast). The general areas are intended to provide additional context for the location of ecosystem services in the region. This challenge was not encountered in other regions, so corresponding maps were not produced for the other regions.

Table 8.9-3 summarizes the highest priority rating assigned in each region for each ecosystem service.

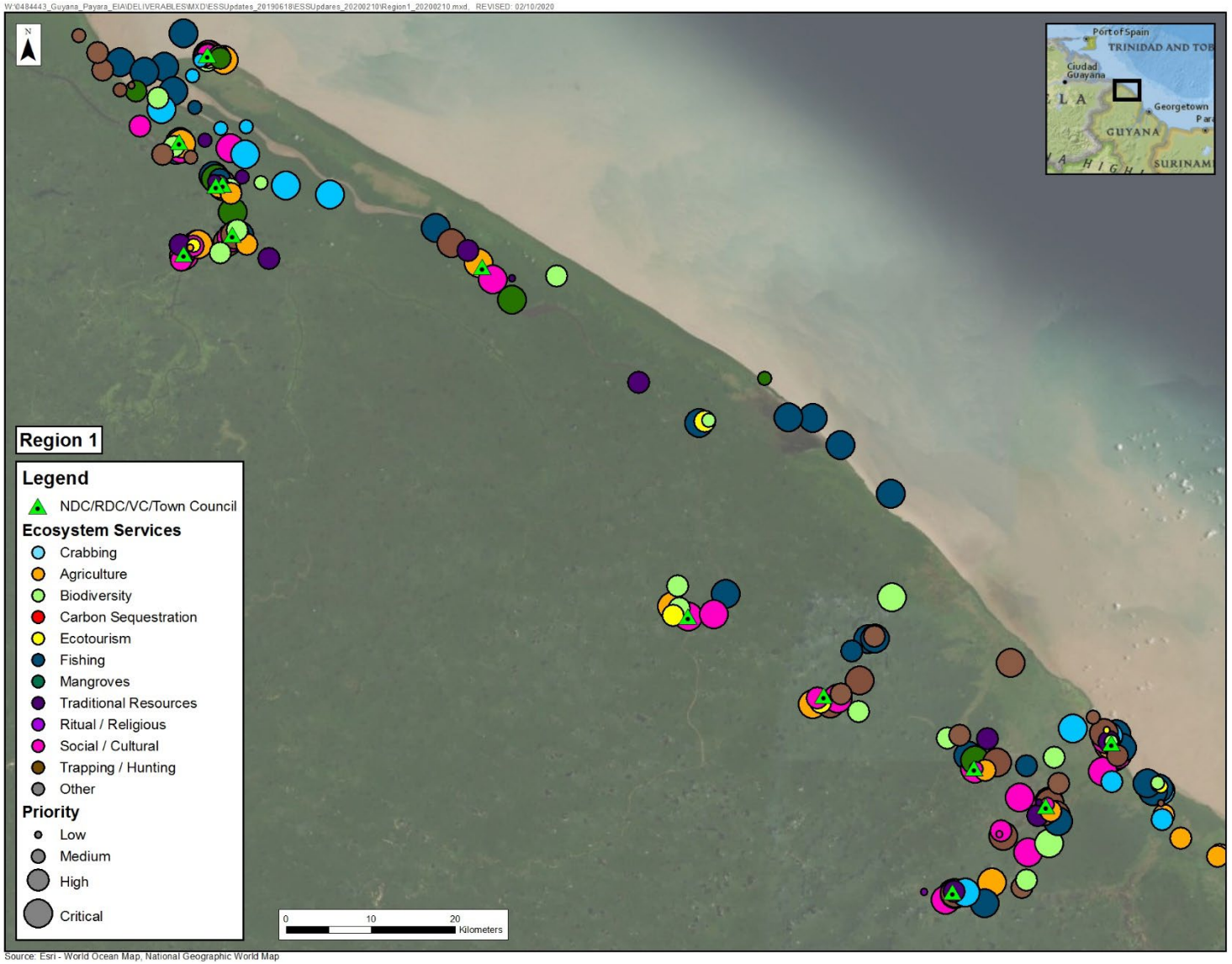


Figure 8.9-3: Region 1 Identified Locations of Ecosystem Services

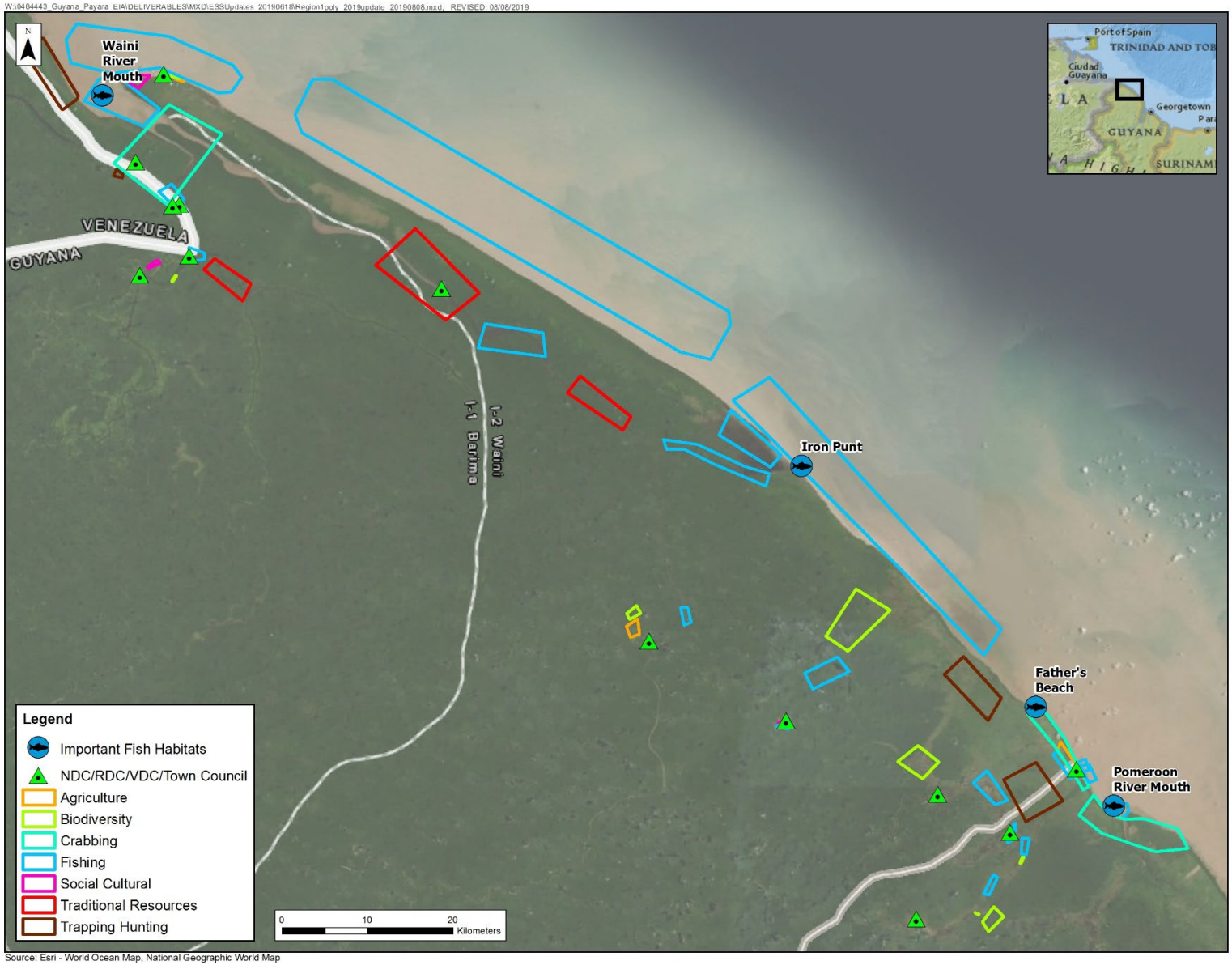


Figure 8.9-4: Region 1 Identified General Areas of Ecosystem Services

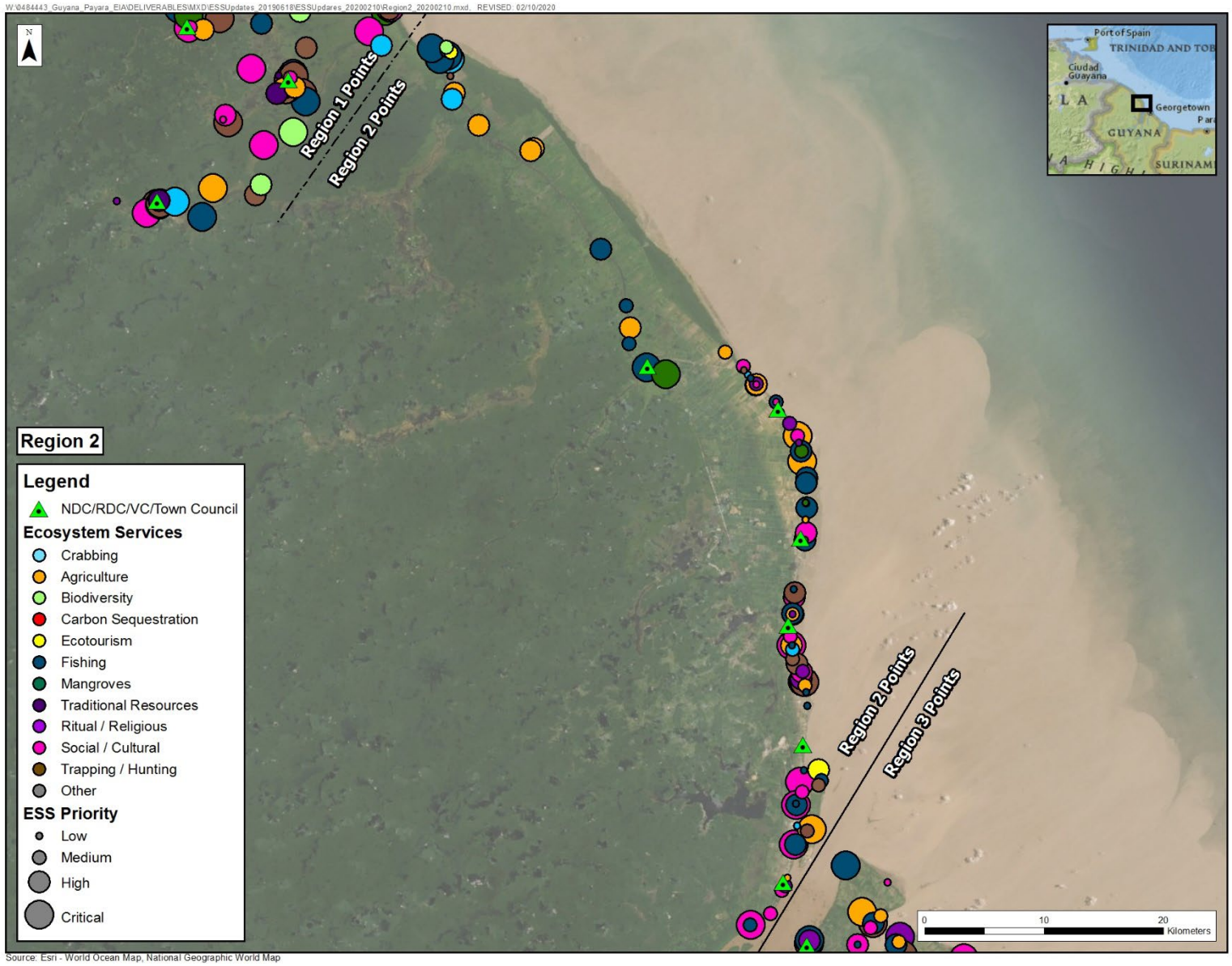


Figure 8.9-5: Region 2 Identified Locations of Ecosystem Services

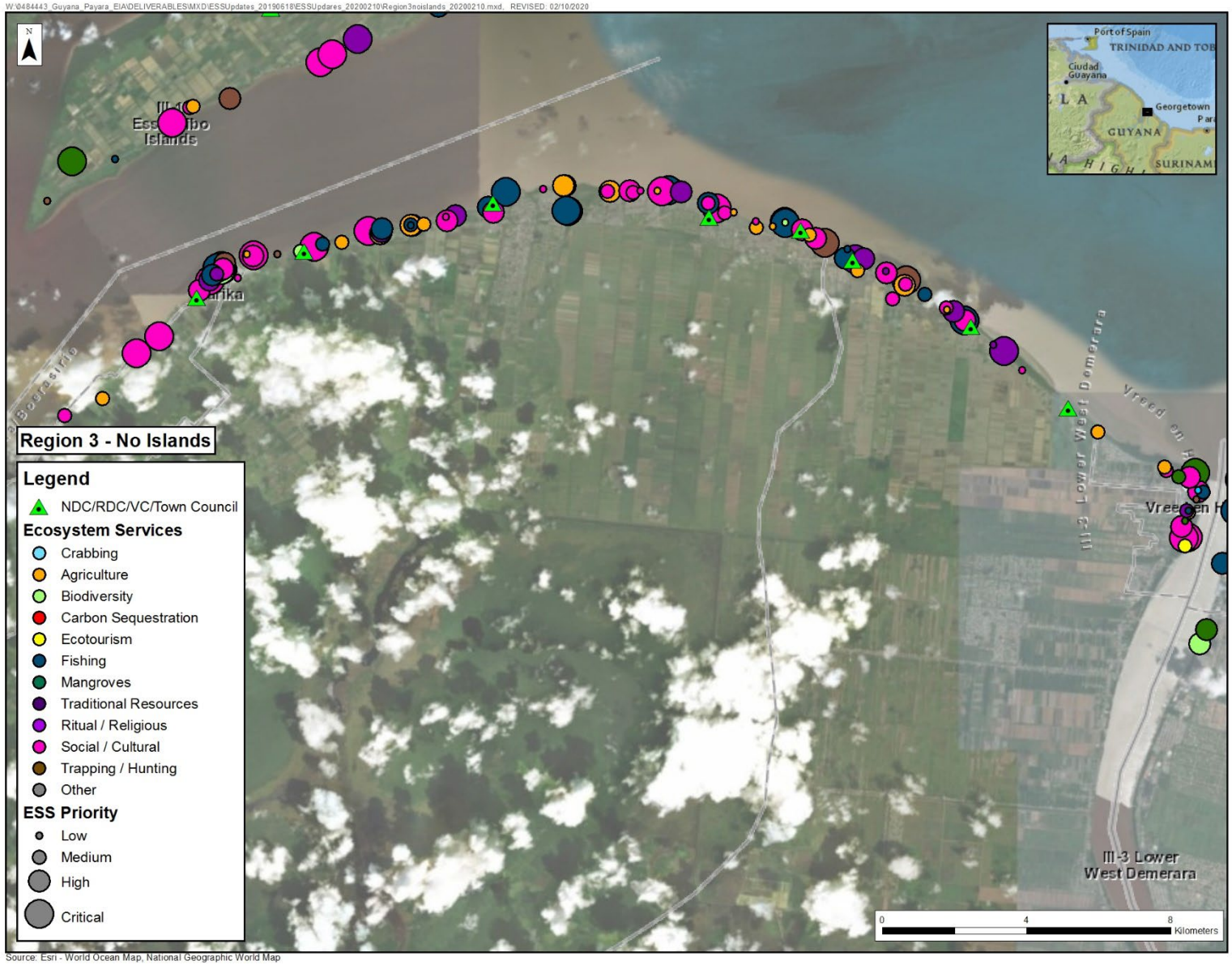


Figure 8.9-6: Region 3 Identified Locations of Ecosystem Services

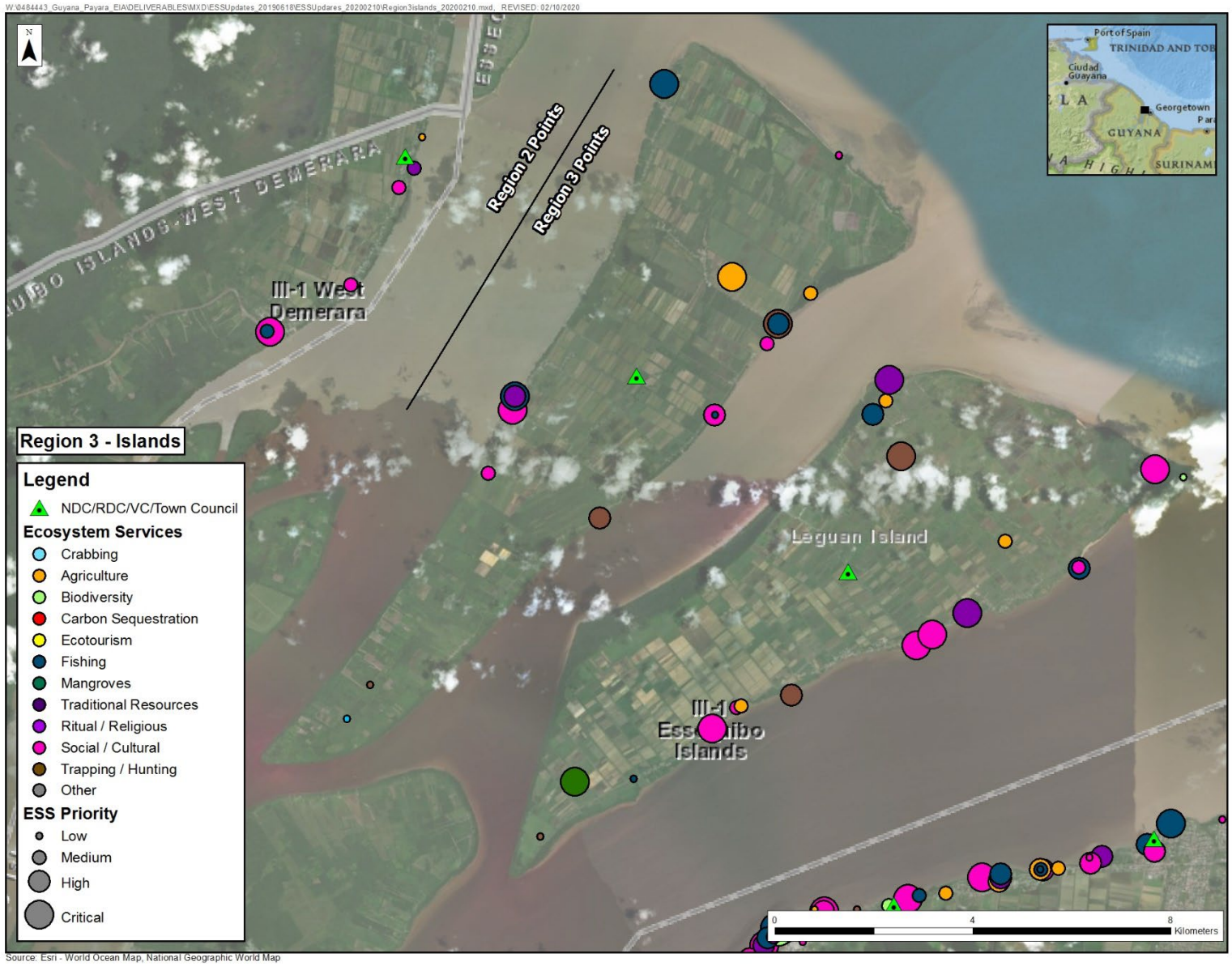


Figure 8.9-7: Region 3 Islands Identified Locations of Ecosystem Services

Figure 8.9-8: Region 4 Identified Locations of Ecosystem Services

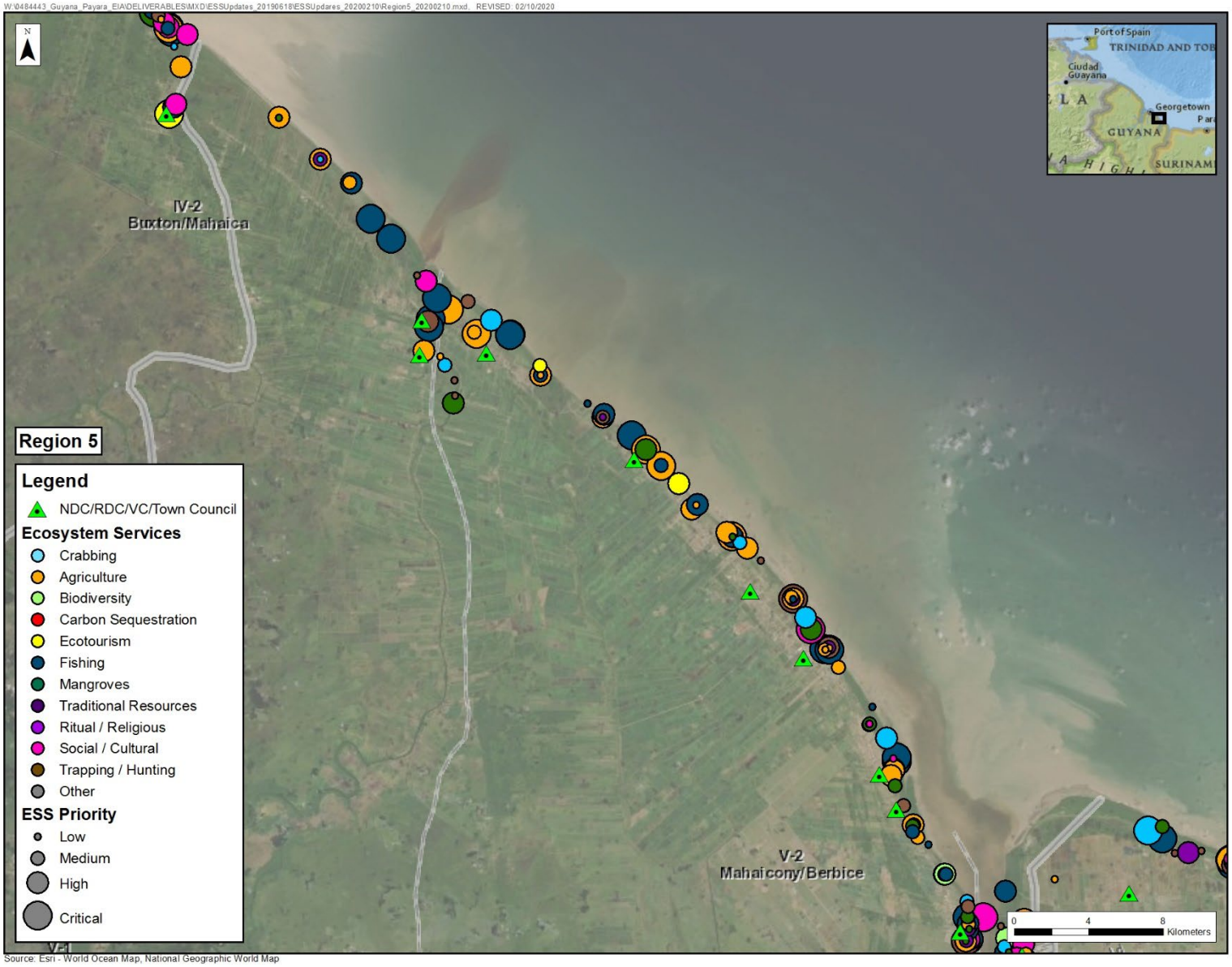


Figure 8.9-9: Region 5 Identified Locations of Ecosystem Services

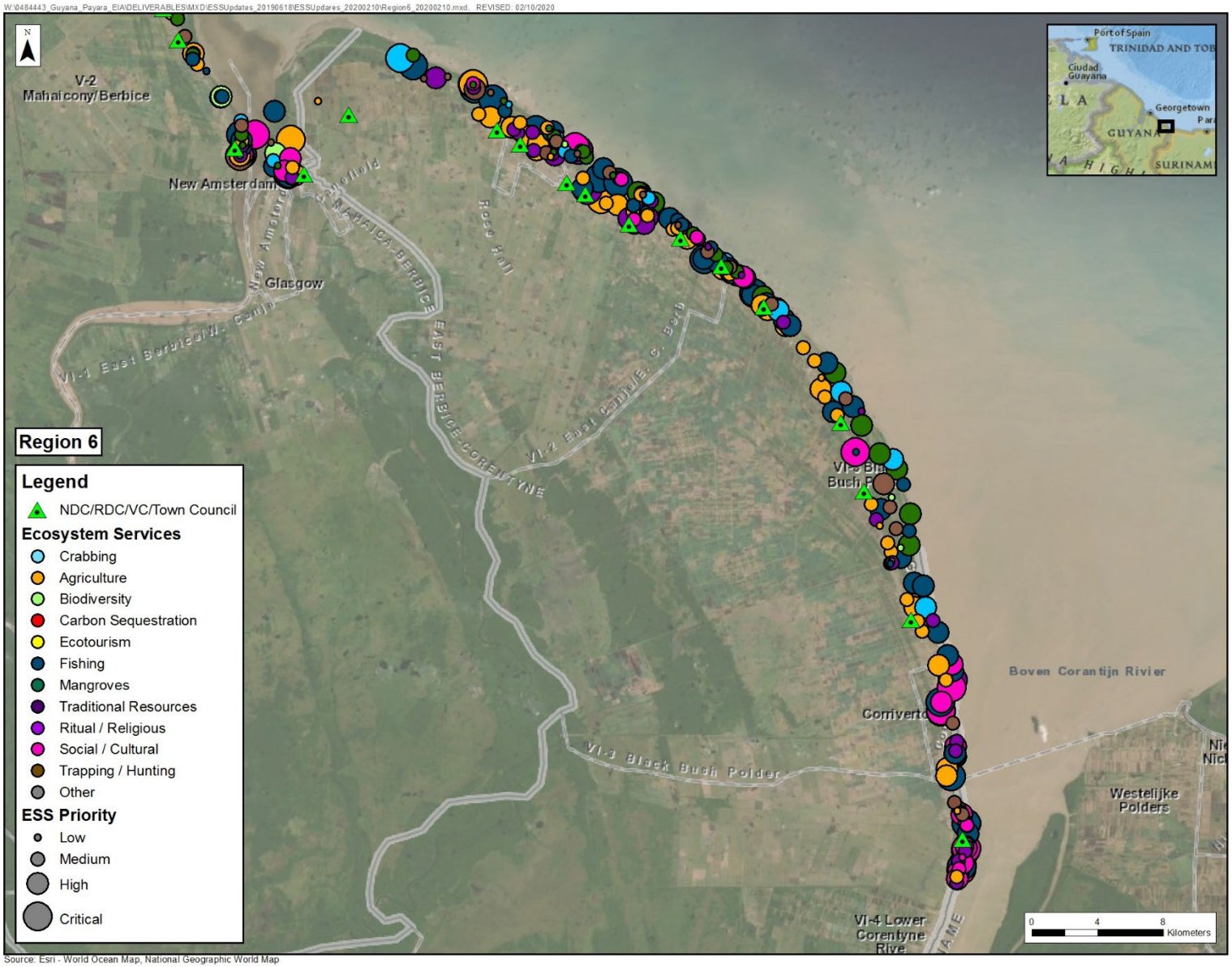


Figure 8.9-10: Region 6 Identified Locations of Ecosystem Services

Table 8.9-3: Highest Ecosystem Service Priority Ratings for each Region

Ecosystem Service Type	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
Provisioning Services						
Marine aquaculture and wild-caught fish & shellfish, including crab (food)	Critical	Critical	Critical	Critical	Critical	Critical
Cultivated crops	Critical	Critical	Critical	High	High	High
Livestock farming	High	High	High	High	Critical	Critical
Food: wild plants and honey	*	NA	NA	Medium	Medium	Low
Food: wild meat	High	High	Low	Medium	Medium	
Biomass fuel	*	NA	NA	NA	NA	NA
Timber and wood products	*	NA	Low	NA	NA	NA
Non-wood fibers and resins	*	NA	Low	NA	NA	NA
Traditional resource use/traditional medicine	High	NA	NA	NA	NA	NA
Freshwater for household use	Critical	NA	High	NA	NA	NA
Freshwater for irrigation use	NA	NA	Critical	NA	NA	Medium
Aquatic transportation/ports	Critical	Critical	Critical	Critical	Critical	Critical
Social/economic commercial activity	Critical	Medium	Critical	Critical	Critical	Critical
Social/housing	High	NA	High	Critical	Low	High
Regulating Services						
Global climate regulation	NA	NA	NA	NA	NA	NA
Regulation of water timing and flows	NA	NA	NA	NA	NA	NA
Flood regulation	NA	NA	NA	NA	Critical	
Erosion regulation	Critical	Critical	Critical	Critical	NA	NA
Shoreline protection/mangroves/river defense	Critical	High	Low	High	Critical	High
Pest regulation	NA	NA	NA	NA	NA	NA
Pollination	NA	NA	NA	Medium	NA	NA
Disease regulation	NA	NA	NA	NA	NA	NA
Cultural Services						
Cultural, religious, or spiritual value	Low	Critical	Critical	Critical	Critical	Critical
Aesthetic value of natural landscapes, historical landmarks	NA	Medium	Low	High	NA	NA
Tourism and recreation			Critical	Critical	Critical	Critical
Non-use value of biodiversity	NA	NA	NA	NA	NA	NA
Supporting Services						
Habitat provision, coastal protection	High	Critical	Critical	Medium	NA	High
Primary production, biodiversity	Critical	NA	NA	Critical	NA	NA
Nutrient cycling	NA	NA	NA	NA	NA	NA

Ecosystem Service Type	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
Water cycling	NA	NA	NA	NA	NA	NA
Soil formation	NA	NA	NA	NA	NA	NA

NA = not applicable as not deemed present or valuable by beneficiaries or stakeholders during screening and scoping exercises
* Service identified in the region but as part of traditional resource use/traditional medicine

8.9.3. Impact Assessment—Ecosystem Services

Although the planned Project activities will have potential minor impacts on water quality, benthic communities, and marine wildlife, these potential impacts are not expected to significantly impact offshore ecosystem services. Specifically, the Project's planned offshore activities are not expected to impact the processes that regulate the physico-chemical attributes of the North Brazil Shelf Large Marine Ecosystem as a whole (e.g., water quality, currents, oceanographic conditions, bathymetry), nor are they expected to cause significant impacts on fishery production offshore Guyana.

The only potential impacts from planned Project activities in nearshore marine waters will be those related to an incremental increase in ship traffic in and out of Georgetown Harbour as ships transit between the shorebases and the PDA. This incremental increase is not expected to result in an impact on marine fauna that would lead to any significant impacts on the availability of marine fauna as an ecosystem service. Therefore, the Project's planned activities are not expected to impact ecosystem services provided by the nearshore marine ecosystem.

The planned Project activities will not involve any direct disturbance of coastal habitats and the Project's air emissions, discharges to water, and sound generation, all of which will occur approximately 203 kilometers (approximately 126 miles) northeast of the coastline of Georgetown, will not result in significant impacts on these habitats. Project use of the Guyana shorebases and onshore support facilities will have no impact on ecosystem services.

The Project's potential impacts on ecosystem services as a result of an unplanned event are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

8.9.4. Management Measures—Ecosystem Services

As there are no potential impacts on ecosystem services as a result of planned Project activities, no mitigation measures are proposed.

8.10. INDIGENOUS PEOPLES

8.10.1. Administrative Framework—Indigenous Peoples

Table 8.10-1 summarizes the legislation, policies, or treaty commitments that are specifically relevant to the assessment of potential impacts on Indigenous Peoples.

Table 8.10-1: Legislation, Policies, or Treaty Commitments—Indigenous Peoples

Title	Objective	Relevance to the Project
Legislation		
Amerindian Act (2006) Cap. 29:01.	Provides for the recognition and protection of the collective rights of Amerindian villages and communities, the granting of lands to Amerindian villages and communities, and the promotion of good governance with Amerindian villages and communities.	Within the broad context of protection of the collective rights of Amerindian villages, this could include the right of use of coastal resources for traditional and subsistence activities, which could be affected in the unlikely event of an oil spill from the Project.
International Declarations Signed/Acceded by Guyana		
United Nations Declaration on the Rights of Indigenous Peoples (2007)	A comprehensive statement addressing the rights of Indigenous Peoples. It emphasizes the rights of Indigenous Peoples to maintain and strengthen their own institutions, cultures, and traditions and to pursue their development in keeping with their own needs and aspirations. Further, it addresses both individual and collective rights, cultural rights and identity, rights to education, health, employment, and language, among others.	Guyana's adoption of the Declaration creates an expectation for the Project to include engagements with Indigenous Peoples and take necessary measures to respect their rights.
American Declaration on the Rights of Indigenous Peoples (Organisation of American States) (2016)	Offers specific protection for Indigenous Peoples in North America, Mexico, Central and South America, and the Caribbean. Affirms the right of self-determination; rights to education, health, self-government, culture, lands, territories, and natural resources; and it includes provisions that address the particular situation of Indigenous Peoples in the Americas, including protections indigenous women and children, and those living in voluntary isolation, among others.	Guyana's adoption of the Declaration creates an expectation for the Project to include engagements with Indigenous Peoples and take necessary measures to respect their rights.

8.10.2. Existing Conditions—Indigenous Peoples

Guyana's Indigenous Peoples, referred to as Amerindians (a term defined in the Amerindian Act to represent Guyana's First People), numbered 78,492 as of the 2012 census (the most recent national census) and their population is on the rise, with growth of 12.8 percent seen in the period 2002–2012 (BSG 2012). According to the 2012 census, Amerindians comprised 10.5 percent of the population and their numbers have nearly doubled since 1980 (see Table 8.10-2).

Table 8.10-2: Distribution of Population by Ethnic/Nationality Group (1980–2012)

Ethnicity Background	Population				Percentage			
	1980	1991	2002	2012	1980	1991	2002	2012
African/Black	234,094	233,465	227,062	218,483	30.8	32.3	30.2	29.3
Amerindian	40,343	46,722	68,675	78,492	5.3	6.5	9.1	10.5
Chinese	1,864	1,290	1,396	1,377	0.3	0.2	0.2	0.2
East Indian	394,417	351,939	326,277	297,493	51.9	48.6	43.4	39.8
Mixed	84,764	87,881	125,727	148,532	11.2	12.1	16.7	19.9
Portuguese	3,011	1,959	1,498	1,910	0.4	0.3	0.2	0.2
White	779	308	476	415	0.1	0.04	0.06	0.06
Other	294	107	112	253	0.04	0.01	0.01	0.03
Total	759,566	723,671	751,223	746,955	100	100	100	100

Source: BSG 2012

Amerindians are found in significant numbers in the Hinterland Regions. Amerindians make up 85.8 percent of the resident population in Region 9; 72.3 percent in Region 8; 64.6 percent in Region 1; and 37.2 percent in Region 7 (see Table 8.10-3).

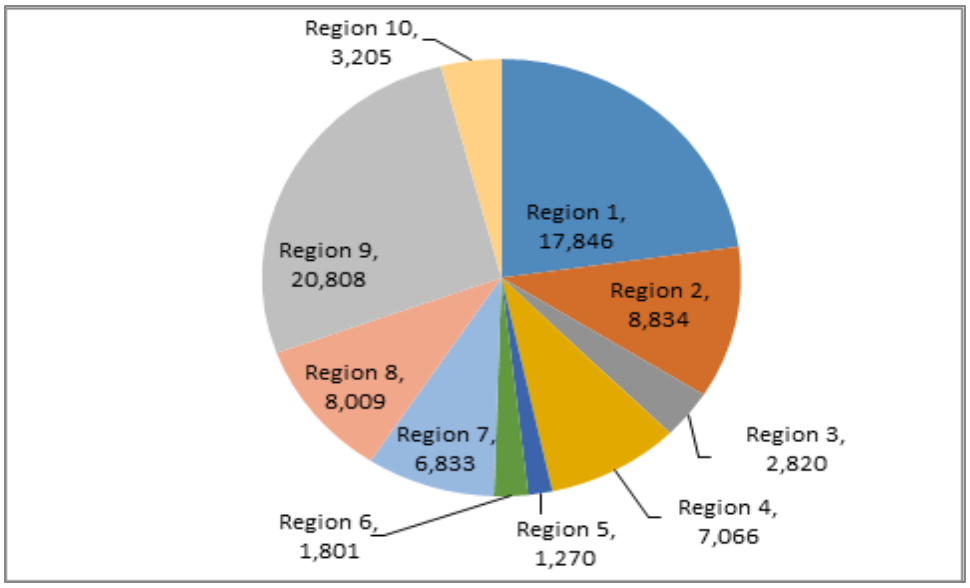
Table 8.10-3: Percentage Distribution of Ethnic/Nationality Group by Region (2012)

Ethnic Background	Region										
	1	2	3	4	5	6	7	8	9	10	Total
African/Black	2.30	12.58	21.13	40.56	33.06	21.32	11.62	7.75	1.46	49.02	29.25
Amerindian	64.56	18.87	2.62	2.27	2.55	1.64	37.19	72.30	85.85	8.01	10.51
Chinese	0.05	0.09	0.18	0.24	0.09	0.16	0.14	0.08	0.04	0.32	0.18
East Indian	1.71	44.57	59.55	35.02	54.66	66.03	8.54	2.55	1.04	2.82	39.83
Mixed	31.17	23.60	16.38	21.45	9.51	10.69	40.89	16.59	11.17	39.63	19.88
Portuguese	0.17	0.22	0.08	0.37	0.08	0.07	1.21	0.69	0.30	0.10	0.26
White	0.04	0.07	0.03	0.06	0.03	0.05	0.05	0.05	0.12	0.08	0.06
Other	0.01	0.00	0.05	0.03	0.01	0.02	0.36	0.00	0.02	0.03	0.03
Total	100	100	100	100	100	100	100	100	100	100	100

Source: BSG 2012

According to Minority Rights Group International (2018), there are nine main Amerindian groups in Guyana, of which three are coastal: the Carib, Warrau, and Arawak tribes. Other groups tend to inhabit the country's Hinterland Regions. Many of the Amerindians in the coastal area have culturally integrated with the general population. They share many of the same livelihoods as the Afro- and Indo-Guyanese coastal populations; however, as a whole, the standard of living

for the Amerindian population is lower than for the general population, particularly for those in remote areas where providing infrastructure and services is a challenge. The distribution of Amerindian population among the regions is shown on Figure 8.10-1.



Source: BSG 2012

Figure 8.10-1: Amerindian Population by Region, 2012

Region 1 and parts of Region 2 are not accessible by road. Amerindian communities in these areas are remote and are generally underserved by public infrastructure and services. These populations make use of a range of coastal resources for subsistence and livelihoods, including fishing and crabbing, as well as small-scale agriculture and hunting. Amerindian communities that are directly adjacent to the coast include Father's Beach and Almond Beach, which are untitled communities, as well as the titled community of Three Brothers along the Waini River, directly inland from Shell Beach. There are a few untitled communities in close proximity to the shore zone, including Imbotero and Smith's Creek. The principal titled indigenous communities located 5 to 10 kilometers (approximately 3 to 6 miles) inland from the coast include Santa Rosa, Waramuri, Manawarin, and Assakata in Region 1, and Wakapau, Mainstay/Whyaka, and Capoey in Region 2 (although these communities have limited interaction with the shore zones or associated coastal ecosystem) (ERM Personal Communication 20).

In the SBPA, fishing and crabbing occur at the westernmost end of Shell Beach, at the mouth of the Waini River. In this area, the Almond Beach community is engaged in coconut and other crops farming. Many communities from Regions 1 and 2, and inland from the coast, also venture to Shell Beach's easternmost coastline near the mouths of the Moruca and Pomeroon rivers to engage in these activities (ERM/EMC 2018). Also in this area, near Father's Beach, there are coconut plantations used for manufacturing oil and crop farming, and just northwest of this is a forested area where hunting, trapping, fishing, crabbing, crabwood seed harvesting, and lumbering occurs (PAC 2014). See Figure 8.10-2 for a map of these communities.

In the other regions, titled indigenous communities are located inland and not in proximity to the shore zone or coastal areas.

During the 2019 ecosystem services field validation efforts conducted in Region 1, stakeholders revealed that there has been an influx of migrants from Venezuela into some of the villages. These migrants have been fleeing economic hardship and have included returning Guyanese who had previously migrated to Venezuela, as well as Venezuelan nationals. The township of Mabaruma has reportedly had the greatest number of migrants, estimated to be around 1,000. However, residents claimed that thousands more passed through the community within the past year. Some indigenous communities have also reported to have a significant amount of migrants present, including Imbotero, Smith's Creek, and Warapoka. Regional leadership acknowledged that the influx of persons from Venezuela is placing a strain on government resources in Region 1, especially social services (health, education, housing, etc.).

Cross-border migrants continue to receive assistance from the Government of Guyana and/or its international partners. UNICEF partnered with national agencies to ensure the documentation of children and the provision of services such as education, protection, and sanitation and hygiene interventions as well as language classes for migrants to learn English as a second language (Rhodius 2020). The International Organization for Migration implemented a Flow Monitoring Survey of migrants from 2018 to 2019 in addition to providing humanitarian relief and skills and entrepreneurship training.

The influx of indigenous migrants from Venezuela into the communities continued through 2020 and 2021, and community representatives in Region 1 have reported that the strain on the natural resources of the communities has continued with the immigration. Migrants have contributed to an increase in fishing and hunting and the use of mangrove forests for building materials.

According to indigenous community leaders, the COVID-19 pandemic has severely impacted communities and livelihoods. Demand for products such as fish and crabs has dwindled, leaving residents with reduced incomes. The supply of commodities into the community has also been affected, leading to rising prices for basic commodities, and consequently increasing locals' reliance on natural resources for hunting, fishing, and other harvests. While some communities in Regions 1 and 2 have worked to develop local tourism services, tourism activities have been broadly suspended, further exacerbating the decline of local economies (ERM Personal Communication 29).

Given the potential importance of the Region 1 coastal communities in the unlikely event of an unmitigated oil spill from a well control event (see discussion in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events), basic socioeconomic and community health-related data at the village level are presented below for the 14 Amerindian communities depicted in Figure 8.10-2. This information was obtained during the April 2018 ecosystem services fieldwork completed in Region 1 by the Consultants (ERM/EMC 2018). Where appropriate, it has been updated based on the ecosystem services study (ESS) field validation efforts completed in June 2019 in the same villages in Region 1 (Appendix S, Enhanced Coastal Sensitivity Mapping—Ecosystem Services Final Report).

Community engagement activities in August and September 2021 sought updates to the Project's understanding of existing conditions in indigenous communities in Region 1 and Region 2. Through this engagement, the impacts of the COVID-19 pandemic, widespread flooding, and other significant changes in 2020 and 2021 were identified. Common themes that emerged from discussions with community-level representatives included:

- Severe flooding events in 2021 have had a lasting impact on communities through the destruction of farmland, loss of cash crops and subsistence crops, and impacts to residential areas. Livestock holdings were also affected, although livestock rearing is not as extensive as in other regions. The damage to farmland is expected to take many years to recover in some cases.
- The COVID-19 pandemic has contributed to economic hardship as people have been unable to work, and small local businesses (including local grocers) have closed (permanently or temporarily).
- Both flooding and COVID-19 impacts have contributed to increased commodity prices, decreased incomes, and rising food insecurity for residents of Indigenous communities. Many households are reported to be drawing on savings and/or relying on monies sent by family members living outside of Guyana.

Some Amerindian communities in Regions 1 and 2 were further engaged through the Participatory Fish Study (EMC 2021; described further in Section 8.4 Marine Use and Transportation), including landing sites at Smith Creek and Waramuri/Haimokabra in Region 1, and Charity, Hampton Court, and Lima in Region 2.

Figure 8.10-2: Region 1 Amerindian Communities

8.10.2.1. Father's Beach Community

The community had approximately 23 people in 2019, declining rapidly from 47 in 2018 due to migration. There has been a continued steady decline in the population over the years from a peak of more than 300 persons (in the recent past) and it is currently comprised of persons from other communities such as Pomeroon River, Santa Rosa, and Haimokabra. The primary economic activity is sale of fish and crops, as well as a small boat building and repair facility that also sells fuel. The village provides rescue and repair services to stranded fisherfolk offshore. There is a school in the village, but it is not in use since there are only a few children who instead attend school at Waramuri. Although residents are Amerindian, the community is not a titled Amerindian community.

Access to the community is through one small canal, which makes access a challenge and entirely dependent upon tides. The community is surrounded by mangroves that protect it from the ocean. The land is comprised of mangroves, agriculture, and irrigation. In the past, the area had fertile coconut groves but some of these are now degraded due to the natural erosion cycles of mangrove growth, as well as burning practices in which community members have attempted to develop ditches for aquaculture use. The biodiversity in the area consists of jaguars, larger flocks of macaws, deer, agouti, wild ducks, and labba. Occasionally, deer, wild hog, iguanas, ibis, scarlet ibis, or heron are hunted for subsistence only. No hunting or trapping by outsiders is allowed.

Agriculture and fishing are the most important economic activities for the community, and a variety of crops are farmed for subsistence and sale, including vine crops, cassava, passion fruits, plantains, and other crops (pepper, tomatoes, okra, etc.). A renewed focus is on coconuts, with one family harvesting the 3-month crop in between fishing seasons and selling the coconuts in Charity where demand is high. The primary fishing areas include inland fishing along the coast behind the mangroves and coastal fishing with a focus at the mouth of the Pomeroon River and the canal entrance to Father's Beach. Coastal catch includes catfish, snouk, trout, banga, basha, snapper, mullet, catfish, curass, and butterfish. Fish caught inland include hassar, houri, sunfish, and yarrow. One family is engaged in boat building and repairs as well as fuel retailing.

Crabbing in mangroves along the beach area is also common, especially during the crab seasons, and residents from several villages, including as far as Pomeroon and Warapoka, come into Father's Beach to crab. Locals have complained that the amount of crabs burrowing has been causing damage to the dams, which are critical for flood prevention and drainage in the community. Other community members catch crab throughout the year for both subsistence and commercial purposes.

Source: ERM/EMC

Figure 8.10-3: Father's Beach Community

There are reportedly no longer any living cultural heritage sites important to the community and reportedly no traditional religious practices undertaken in the community. They do use local resources such as red mangrove to make crafts and household items. Mangrove is currently the only source of hardwood and it is harvested inland to make poles for plantain trees. Buttonwood bark is used to make quake strings and shovel sticks. For recreational purposes, the communities use Gwennie Beach, Papaya Beach, and Bolton Area. The shells along the beach are used by residents for constructing building foundations, filling yards, and placing around fruit trees to provide nutrients. Several plant species, including noni, are used for medicinal purposes.

A health hut was not in use in 2019, with community members traveling to Charity, Moruca, and Waramuri to receive healthcare services. Government health teams have not visited the community in years, and childbirth typically occurs at home because of the transportation constraints. There have been no recent reported malaria cases. Common cold, diarrhea, fever, and vomiting (typically contracted when outside the community) are most common, and community members use traditional medicine to heal. The primary water source is from rainwater harvesting and typically, during the dry season, the community will buy bottled drinking water from Charity.

8.10.2.2. Manawarin Village

The population of the community in 2019 was more than 2,000, increasing from 1,862 people in 2018, and the primary economic activity is commercial fishing as well as small-scale sale of fish. Access to the community is through the Manawarin River, a branch of the Moruka River. One primary school had 388 students enrolled in 2019, and a nursery had 86 infants attending in 2018. Students in higher grades attend school at Santa Rosa Secondary. The village has its own village office, health center, multipurpose building, and playground. A major challenge in the community is lack of livelihoods and access to markets for commercial purposes. Another critical challenge is the intrusion of salt water into the community fishing grounds during the dry season.

The village is in close proximity to intact forest ecosystems with a high diversity of freshwater fishes, birds, and mammals. Wild hogs, tapir, labba, parrots, macaws, jaguars, panther, curry-curry (a local name for scarlet ibis), powis, marudi, and river otters can be seen in the forests and sometimes in the savannas.

Agriculture is important for livelihoods, and virtually all families farm cassava for subsistence. The staple diet is cassava and fish, with flour and rice purchased from Charity. Approximately one-fourth of the population depends on fishing for their livelihoods and both freshwater and saltwater fishing are common. Within the freshwater areas, people fish for lukanani, patwa, houri, yarrow, and sunfish, among other species. Fishing in the ocean was more prevalent in the past, but is declining due to the cost of engines and boats required for the long journey.

Source: ERM/EMC

Figure 8.10-4: Manawarin Village

Most people from the village access the shoreline to catch crabs during the crab season. In addition, a few people catch crabs year round and bring them back to the village for sale. It is estimated that about one-fourth of the village is involved in hunting. Birds are often caught for sale and mammals are caught for subsistence.

One important living cultural heritage site called Rockstone is located up river, but there are reportedly no active traditional religious practices. Local resources, including palms and vines (ite, kufa, nibbi, and kufra), are used for making crafts and household items. Manicole palm was previously harvested and sold, but this is not currently common practice.

As of 2019, the village health clinic had two community health workers, but no doctor, nurse, or midwife. The clinic commonly addresses issues related to hypertension, diabetes, and post-natal and family planning. Health workers see approximately 40 people a day, mostly children for fever and cold symptoms. In an emergency, citizens rely on private transportation to Waramuri, Charity, or Kumaka. Medical supplies and medicines are in short supply and come from Kumaka, but the dates are reportedly normally close to expiration. Skin conditions are especially prevalent with babies. Water is not treated and gastroenteritis cases are common after the rainy season.

8.10.2.3. Haimokabra Village

The community is considered a satellite community of Waramuri and, as of 2018, had a population of approximately 600 people. The primary economic activity is sale of fish; however, in 2019, more than 100 people were employed in mining in the interior regions. There is one primary school that had 149 students in 2018; some students also attend school in Waramuri.

Agriculture is important to the community for livelihood and all households have farms and use higher lands not vulnerable to flooding for cultivating crops, specifically cassava. The staple diet is cassava and fish. Much of the village land consists of flooded savannas, which are burned as part of traditional burning practices in the dry season. The highland areas are forested and have some valuable species of hardwood used for construction in the village. The area also has a considerable number of fish and other wildlife. Trapping of parrots, toucans, and macaws is common for sale to traders and eventual resale in Charity.

Fishing is the main economic activity, with approximately half of the male population involved in the activity for both subsistence and commercial purposes. Fishing occurs out to approximately 8 kilometers (5 miles) on both sides of the Moruka River mouth in the ocean, by the use of hook and line and drift seine. Fishing trips range from daily to weekly and fisherfolk sometimes camp along the beach in the vicinity of Iron Punt, where they fish in the lagoon behind the beach. Fish are sold in the village, as well as other areas such as Waramuri and Kumaka. Freshwater fish are caught from streams within and surrounding the community. Crabs are caught seasonally by almost everyone in the village, as well as regularly by 10 to 12 people for sale at the weekly market. Lumbering is also prevalent, with about 20 chainsaws operating within the community. Each chainsaw operation employs about six people.

Source: ERM/EMC

Figure 8.10-5: Haimokabra Village

In 2018, the village had more than 100 young men employed in various mines in the interior who work for about 3 months at a time. This influx of funds helps the village economy in general; however, villagers reported that it is common for many young men to return home alleging of not being paid by the mine for their labor.

There is an important cultural site in the form of a shell mound located within the community, and it is protected due to the low level of human traffic to the location. Mangroves along the shore are used to make fishing poles. Honey is collected from wild beehives along the coast in an opportunistic fashion.

The community has a solar-powered groundwater well that discharges into storage tanks from which gravity flow distributes the water to users. However, the system is not functioning properly, and community members lack the equipment to conduct a repair. A computer lab building was erected, but equipment has never been provided. Most people in the village have cellular phones, but few persons reportedly use them to access the internet.

The village has a health clinic with two community health workers but no doctor, nurse, or midwife in 2018. The health workers see an average of 20 people per day, with the most prevalent cases being flu/fever and hypertension. There are no laboratory facilities, and in the case of fevers, residents must pay for private transportation to Kumaka. Despite a high percentage of the population working in the mines, cases of malaria are low. A doctor based out of Waramuri visits some of the outpatients and pregnant mothers once a month. Due to a lack of electricity, equipment, and instruments, pregnant women are typically referred to Kumaka at 35 weeks.

8.10.2.4. Waramuri Village

The community had a population of approximately 2,500 in 2019, consisting of approximately 60 percent females. In 2018, the community had 308 households. The primary economic activity is sale of fish followed by mining in the interior. Some men also work on fishing vessels from Regions 2 and 3 on a rotation basis, with an average of two fishing trips per month. There is one primary school and a nursery school that in 2018 housed 406 students and 40 students, respectively.

Agriculture is important to the community for livelihood, and all families farm cassava for subsistence, with at least three farms growing at different levels of maturity. All households have farms and use land to cultivate crops. Coconut cultivation is increasing and coconuts are sold in Charity. Copra (dried meat or kernel of the coconut) is also harvested and sold.

Fishing is an important economic activity, with approximately 30 percent of the village involved. An average of three boats per week from the community fish along the coastline on both sides of the Moruka River mouth between Iron Punt and Cozier Canal. Saltwater fish (catfish, curass, gillbacker, snapper, basher, and highwater) are sold within the village as well as in neighboring communities. Freshwater fish (queriman, cufum, hassar, lukanani, houri, dari, patwa, yarrow) are caught in the lagoon behind the beach and in streams within and nearby the community.

Crabs are caught seasonally by almost everyone in the village along both sides of the Moruca River between Corkwood and Cozier Canal, as well as regularly by a few persons for sale.

The area has a considerable number of fish and birds, with few people involved in trapping wild animals (tapir, deer, iguana, wild ducks) near the beach for subsistence and commercial use. Honey is gathered from wild bees along the beach and medicinal plants, including noni, are collected from the beach as well as within the community. The ite palm (an indigenous type of palm) is recognized by the village as the tree of life. The palm provides tibisiri, food, roof material, fruit for drink making, other construction material, and the tacoma worm. Tibisiri is made from the fiber from the leaves of the palm and is used to make hammocks, thatch roof, furniture, baskets, and carpets. Tacoma worm, also known as the beetle larvae (*Rhynchophorus palmarum*), feeds on old ite trees that have fallen to the ground. These beetles are full of fat and are considered a delicacy and a good source of nutrients by the indigenous communities that consume them. Waramuri Village claims that it is the oldest Warrau village on the coastland. There are shell mounds, which are considered cultural heritage sites that are important for the community, but all traditional religious practices have reportedly ceased. The shell mounds are alleged to be more than 2,000 years old. The village intends for this site to be developed into a leading tourist attraction in the future as part of the village's plan to enhance ecotourism activities.

The village has a health center staffed with a doctor, nurse, midwife, community health worker, environmental health assistant, maid, and one boat hand. The most prevalent disease is hypertension, although other common ailments include gastroenteritis, flu/fever, sexually transmitted infections, and skin conditions. There are several clinics offered weekly, including maternal/childcare, hypertension and diabetes. Alcohol consumption is banned in the community, so alcohol-related illnesses are not common.

The village has a playground that is used by villagers and neighboring communities. The playground was recently upgraded with support from EEPGL.

Source: ERM/EMC

Figure 8.10-6: Waramuri Village

8.10.2.5. Santa Rosa Village

Santa Rosa is the largest indigenous community in the country, with a population of more than 10,500. Kumaka waterfront has become Santa Rosa's economic hub as well as an important area for neighboring villages and communities. There are three primary schools and two secondary schools in Santa Rosa and satellite villages. The secondary school in Santa Rosa cares for children for most of the Moruka Sub-District of Region 1, with dormitories for males, females, and teachers. The village houses the Region Administrative Office for the Moruka Sub-District, the Education Office, a police station, a District Hospital, and regional offices for the Ministry of Agriculture Mangrove Project and the Guyana Forestry Commission. The waterways provide the main form of transportation between the communities. The village also has an airstrip at Bimiche that was recently rehabilitated.

More than 500 people are employed in the mining and forestry sectors and remain away from the village for long periods at a time. About 100 people are employed in the village by the Guyana Geology and Mines Commission. Other government workers also constitute an important income-earning group of about 50 additional people. The business sector in the community employs more than 200 people directly. The village has more than a dozen shopping centers that offer more than 100 products and employ from 3 to 10 people each. There are more than 20 nightspots that sell alcoholic beverages and food. As of 2019, a shopping mall was being constructed by the VC.

Many households have farms and use the lands behind the airstrip to cultivate crops. The families living on the bush islands use that land to farm and others have farmland further away

on the highlands. Most of the land in the area consists of savannas that flood regularly, and this land is therefore not used except for fishing and occasional hunting.

Fishing is important to the community for livelihood, with more than 100 fisherfolk involved in commercial and subsistence fishing in the sea along the coast from east of the Pomeroon River all the way to Waini Point, but mainly between the Pomeroon River and Iron Punt. These fishing trips can last up to a week, with most people making at least two trips per month to the sea. Inland freshwater fishing is also common in the streams throughout the community and in swamps behind the beach. In the dry season, when turtles are heading to the beach, there is usually a high presence of seaweed in the water that prevents many fisherfolk from setting their nets. Crabs are caught seasonally by almost everyone in the village, as well as regularly by about 20 people who sell them at the local market twice a week.

The area has many species of fish, mammals, turtles, iguanas, monkeys, and birds. Jaguars are found along the beach and within the village. No villagers are involved in legal trapping, as this activity was banned by the VC in 2016. Turtle meat is not openly sold, and offenders can be held accountable by the VC, which is strongly against such actions. Along the coast, muscovy (wild duck) eggs are harvested and iguana hunting occurs. There are some areas where timber and medicinal plants flourish and there are several smaller biodiversity important areas. Swamps located behind the beach serve as spawning grounds for fish species. Luri Creek and Baramani Lake are important areas where villagers conduct hunting of animals.

There is one living cultural/heritage site in the area that is far away and protected by its exclusive location, as well as a 200-year-old church that is considered a national heritage site. There is also a historical site called Lalancha along the Barabara River where there was a battle between the indigenous communities and the Venezuelans. Most traditional religious practices have reportedly ceased. Some villagers make use of medicinal plants such as noni, which grows abundantly along the coast and in the village. Manicole palm is harvested by villagers for their own use. Areas along the coast and the rivers are used for camping and picnicking.

There is one hospital in Santa Rosa called Kumaka District Hospital. As of 2018, the hospital treated approximately 1,000 outpatients per month, with the most prevalent diseases being gastroenteritis (due to poor water quality) and hypertension. Most causes of death are due to strokes and other diseases stemming from hypertension. There is one doctor and several nurses including a midwife. Teenage pregnancy is common, as are home deliveries, the latter due to lack of transportation and no ambulance service. Medical professionals claim there is a prostitution problem, as well as incidences of alcohol withdrawal syndrome.

Source: ERM/EMC

Figure 8.10-7: Santa Rosa

8.10.2.6. Assakata Village

The community had a population of 473 people in 2019, increasing from 345 in 2018 due to population growth not attributed to Venezuelan migration. There is one primary school that housed 95 students in 2018, with higher-grade students attending school in Santa Rosa or Mabaruma. The village has a health clinic, village office, primary school, sports ground, and communications by radio and cellphones. The primary economic activity is sale of fish, while mining in the interior is the main form of employment since there is no commercial economic activity within the community. Some of the men work on fishing vessels from Regions 2 and 3 and make two fishing trips per month for income.

Agriculture is important to the community for livelihood, and all families farm cassava for subsistence. Vegetables and other crops are also grown for food and some are sold to the hot-meals kitchen that serves the local school. Much of the village has land comprising flooded savannas, which are burned during the dry season. There is also a significant area of mangrove vegetation regrowth in the areas that were burned during the 1998 El Niño fire. The village has several waterways that are abundant with fish.

Luri Creek and Baramani Lake are important areas where villagers hunt animals for subsistence (labba, agouti, deer, tapir), but there is no hunting or trapping of illegal species. Birds, including powis and ducks, nest along the Baramani Lake and eggs are collected. There is also a high prevalence of flamingos using the area behind the beach. Within the community, there are three different types of river turtles (Jumbie Axe [scorpion mud turtle], Stink Turtle, and Red Head [labaria turtle]).

Most families visit the coastal area/beach once a month (mainly through Luri Creek to the Iron Punt area) for fishing, hunting, and gathering. Commonly caught fish includes queriman, snook, and curass. In the swamp behind the beach, patwa, houri, and cufum are commonly caught. Crabs are caught seasonally by almost everyone in the village, as well as regularly by a few persons for sale.

While firewood is used on a daily basis by some villagers, many people cook with gas stoves. Some people use noni and other herbal medicines for medicinal purposes. These are collected during trips to the beach. Most men will harvest manicole palm seasonally.

There is a lake within the community that has several traditional stories attributed to it and that could serve as a tourist attraction if infrastructure was available. There are two shell mounds within the community (a large one and a smaller one). As of 2019, the community was developing an ecotourism plan and intending to seek funding from the government or private investment to build their ecotourism potential. In addition, according to data obtained from the National Trust of Guyana, there was a site for preparing and sharpening tools and implements in the village (EMC Personal Communication 6).

Source: ERM/EMC

Figure 8.10-8: Assakata Village

The village has a health center staffed with one community health worker in 2019. The most prevalent illnesses are cold/flu, hypertension, and diarrhea. Approximately 35 patients are seen daily during outpatient services and many are referred to the Kumaka Hospital in Santa Rosa. The community has one boat that assists in cases of medical emergencies, but it is not dedicated to the health facility. There are few cases of malaria but this is likely attributed to the lack of malaria testing equipment and supplies, indicating a possibility that some infected people may go undiagnosed/untreated.

8.10.2.7. Warapoka Village

The population of Warapoka was approximately 650 people in 2019, increasing from 590 in 2018, with more males than females. There were 87 households within the village in 2018. In addition, as of 2019, there were approximately 80 migrants from Venezuela who had joined the community in the past year. There is one primary school that, in 2018, housed 182 students and a nursery with 34 infants. Students in higher grades attend school in Santa Rosa or Mabaruma. The village has a health clinic, village office, and a tourism center/lodge that can house six tourists.

Ecotourism is becoming an important feature of the village economy, with tourist arrivals and activities increasing, especially Guyanese tourists. The caves, petroglyphs, shell mounds, harpy eagle nesting sites, and other attractions within the community serve as attractions for tourists. A guesthouse consisting of six rooms houses visitors during their stay. Sport fishing in Luri Creek was recently added to the tourism package. Twenty people were employed directly in the tourism operation in 2019, increasing from 10 in 2018. The river serves as the main source of water for the community. The primary economic activity is sale of fish, with government workers, hunting/trapping, and tourism as other income generators within the community; fishing in other regions and mining in the interior are also prevalent.

All households live in close proximity to the village center and all have farms and use the highlands close to the forest to cultivate crops, specifically cassava. Some people farm to supply hot meals for the school and the tourism center when tourists are visiting the village. Most men are involved in fishing, particularly along the beach in the Iron Punt area, which is accessed through Luri Creek. About 20 people fish in this area every 2 weeks and catch queriman, snook, basha, cufum, and catfish. Crabs are caught seasonally by almost everyone in the village, as well as regularly by a few people for sale. Shrimp is also caught in the rivers within the community.

Source: ERM/EMC

Figure 8.10-9: Warapoka Village

The village has flooded savannas that have large parts burned in the dry season. Many people make use of the manicole palms harvesting for sale, and about 80 persons were involved in this activity in 2018. There is also a significant area of mangrove vegetation regrowth in the areas that were burned during the 1998 El Niño fire, which allows for an abundance of fish and birds, with many people involved in trapping wildlife for sale. People come to the village to purchase wildlife including snakes, parrots, macaws, and river turtles (red neck, side neck, jumbie head [scorpion mud turtle], and black turtle). In terms of other biodiversity, manatees are also observed in Luri and Muribu creeks and the village has two harpy eagle nesting sites, with one currently active. Luri Creek is very important since it serves as an important food source due to the presence of many species. Some community members gather honey from wild bees at the beach and one family has a professional beekeeping business.

There are many marine species that can be found in the swamp behind the beach at Iron Punt. Wildlife access the area during the high tide when ocean water flows over the low beach in this area. Hunting of iguanas, birds, and wild ducks is conducted on the beach and duck eggs are collected. Within the village, bird eggs are collected seasonally (blue tiger bird and qak). Marine turtles killed by jaguars are sometimes observed on the beach.

Close to its village office, the village has a cultural site that was used by the previous generations of Warraus to make and sharpen tools. There are also caves and petroglyphs within the community, and three large shell mounds (as a well as a few smaller ones) within the reservation. In addition, according to the National Trust of Guyana, ceramics of cultural value were located in the village (EMC Personal Communication 6). Medicinal plants including noni are collected from the beach and mangrove bark is also used for medicinal purposes.

There is a health center in the village, staffed by one community health worker in 2018. The most prevalent illnesses are cold/fever, diarrhea, and vomiting. There are on average 10 patients seen daily, with severe cases being referred to Moruca Hospital or Kumaka Hospital in Santa Rosa. There have been a few reported cases of malaria in the recent past. There are no immunization supplies and medications are limited. All pregnancies that are higher-risk are referred to other facilities at 37 weeks. Villagers must rely on private transportation for emergencies.

8.10.2.8. Three Brothers Village

The community had a population of 120 people in 2019, living in three satellite villages (Lower Waini, St. Johns, and Kachicamo) along a 45-mile stretch of the Waini River. The population has declined from 310 in 2018 due to villagers leaving for other areas with better infrastructure and opportunities. There are two primary schools, one at St. Johns that housed 36 students, and one at Kachicamo that housed 35 students (as of 2018). Students in higher grades attend school at Mabaruma or Santa Rosa.

Source: ERM/EMC

Figure 8.10-10: Three Brothers Village

The primary economic activity is sale of fish followed by agriculture, government work, and commercial activities such as fuel sales. More than 100 men worked on fishing vessels in 2018, making at least one trip per month that can last for 7 days. All households have farms that need to be bolstered by earth to protect against floods. Agriculture is important to the community for livelihood, and all families farm cassava for subsistence along with coconuts that can be sold for water or harvested for copra. Two large farms exist in the area with boats from Trinidad, Venezuela, and Suriname visiting to buy ginger and coconuts grown on the farms. Approximately 90 percent of the village are engaged in the harvesting of manicole, which is done throughout the year.

Fishing is conducted mainly in the rivers, including Luri Creek and the lagoon, with a variety of species caught, including basher, queriman, morocut, curass, cuffum, lou lou, dew fish, and catfish. Beach fishing is common through Luri Creek from May to July, and at Waini Point during the dry season for saltwater species. Crabs are caught seasonally by almost everyone in the village, as well as regularly by a few people for sale. People from other areas come to the village to catch crabs as well. Some villagers are involved in the fuel sales business and some have shops supplying household items.

Much of the village is covered by mangroves that are used for construction, firewood, and planting materials. All abandoned areas are quickly reclaimed by the mangrove forests, as the crabs tend to break up dams and the areas subsequently flood rapidly. Numerous mammals are seen in the area, although no villagers are reportedly involved in hunting/trapping. Wild ducks and other birds are hunted for food. Iguanas and land turtles are used for subsistence or sometimes sold for commercial purposes. River dolphins were prevalent in the past but have not been sighted recently, which many villagers attribute to an increase in speedboats operating within the area and fuel spills in waterways. Both the neotropical otter and giant otter are found within the area, as are harpy eagle nesting sites. There is also a high presence of jaguars that kill domestic dogs and livestock.

This village has no protected sites and all traditional religious practices have reportedly ceased. Mangroves are used for firewood, building materials (red mangrove), fishing poles, and plantain poles. Honey is collected from wild bees throughout the village by residents. The main area used for recreational purposes is Waini Beach, where villagers camp, picnic, and spend holidays, including Easter. There are villagers involved in manufacturing crab oil, and a crab oil press is located within the village. Crab oil is important to the community, and has a number of beneficial uses. Medicinal plants including noni are collected from the beach.

There is a health center, staffed by a community health worker in 2018. The most prevalent illness is related to respiratory distress, mostly in schoolchildren, as well as diarrhea in children and adults from a lack of clean water. There are reported cases of malaria from villagers when they return from the mining areas. All childbirth deliveries are referred to the regional hospital in Mabaruma.

8.10.2.9. Mabaruma Town

The town of Mabaruma has a population of approximately 8,000 people comprising six communities. In 2019, there were reportedly about 1,000 migrants from Venezuela within the community, but many more were alleged to pass through on a daily basis. The primary economic activity is business/commerce, as this is the key administrative and business center of the region. Fishing and its related services are next in importance, followed by agriculture and government workers. There are six nursery schools, eight primary schools, and two secondary schools within the new town council. The town has a hospital, a police station, a magistrate's court, a military base, a Coast Guard base, regional administration offices, and numerous government offices.

Agriculture is important to the community for livelihoods and many families, particularly in the outlying areas, farm cassava for subsistence and cash crops for sale or daily use. Some communities are involved in fishing, including Waicaribe, Koriabo, Smith's Creek, and Aruka Mouth. Crab are caught daily for sale at Kumaka and to hucksters working on the ferry to Georgetown. Blue crabs are found year-round but red crabs are seasonal. Some villagers work in beekeeping, which is facilitated by a Community Development Project. The major land use in the area is housing/business or administrative services, with numerous wharfs and boat landings in the rivers. Some large farms are still functional, with others converted to grazing for the over 300 head of cattle in the township. Community members are also involved in the harvesting of manicole palm, especially where there are manicole groves.

The villages have more than 500 men employed in various mines who work for between 3 and 6 months per year before returning home. Many miners, traders, and sex workers pass through the area, adding to commercial activity in the town.

The area has a variety of fish species, as well as mammals and birds with a few people involved in trapping and one major trader operating at the Kumaka Wharf. Most of the fish and meat are imported from other areas, with many small businesses now producing chickens. Trapping and hunting are conducted mainly along the riverbanks, and iguanas, labba, agouti, and wild ducks are the main animals hunted. Many bird species are also trapped, especially toucans, macaws, and parrots. It is estimated that there are 100 trappers within the area and three traders based at Kumaka. Sting rays are observed up river and previously dolphins were observed up to Morawhanna but are reportedly no longer sighted.

The town has a few shell mounds, tourist attractions, and a newly constructed park. All traditional religious practices have reportedly ceased, with the majority of people being Christians, with a few Hindus and Muslims. Medicinal plants are harvested from the beach area and mangroves are used by people living in swampy areas for construction and building materials. Mangrove barks are also harvested for use in tanning. The township has three sawmills that provide dress lumber to the town and nearby communities. The owners have timber concessions and also purchase timber from the Amerindian communities upon order. There is a current boost in the building sector that has been good for the three sawmills.

Source: ERM/EMC

Figure 8.10-11: Mabaruma Town

The township has embraced the spirit of Guyana's strategies for sustainable and low-carbon development and with support from the central government built a "Green Park" at Hosororo and planted more than 1,000 trees in the town. It also has a solar farm that generates power for the electric grid. There are plans to install a wind farm as well to provide power for the residents.

There is a regional hospital in Mabaruma, staffed in 2018 with two doctors, five staff nurses, four nursing assistants, four midwives, and two additional midwives dedicated to the maternal and child health clinic. The most prevalent illnesses are hypertension, diabetes, and acute respiratory infections. Despite being the most frequented hospital in the region, there is often a shortage of medication and anesthetics, so operations are uncommon.

8.10.2.10. Aruka Mouth Village

The community had a population of approximately 300 people in 2019, increasing from 180 in 2018, with an approximately equal male/female ratio. The primary economic activity is commerce, with many persons trading in fuel, household items, fresh/salted fish, and crabs; there is very little tourism in the community. The community is considered a part of the Mabaruma Town Council. There is one primary school that housed 48 students in 2018; higher grades attend school at Mabaruma or Hosororo.

Many people have shops and trade in fuel, but 80 percent of the population is focused on fishing and manicole palm harvesting. Fishing is done in both the ocean and rivers in the vicinity of the community. Fishing is a common local activity and many men work on fishing vessels, catching fish for the weekly markets at Kumaka and also catching crabs. Fishing yields have reportedly decreased over recent years, and locals attribute this change to increased incidence of excessive rainfall, flooding, and high tides.

Shrimp is caught during certain periods. Crabs are prevalent during the crab season when all households contribute to crabbing, while five households specifically supply the twice-a-week market at Kumaka. Some households have farms and use the lands to cultivate crops (when there is no flooding) for subsistence and sale at the local market. Community members claim that most of the aquatic mammals have moved away due to increased fuel in the water. A few households are involved in the harvesting of manicole palms. Hunting is not common.

There are no cultural sites and traditional religious practices have reportedly ceased. Some medicinal plants are collected from within the community. Mangroves are utilized by persons living in swampy areas as posts for construction and for building foundations and firewood. Some people utilize the Kissing Rocks and the beach for recreational purposes.

The community does not have a health facility and residents must go to the Mabaruma Regional Hospital.

Source: ERM/EMC

Figure 8.10-12: Aruka Mouth Village

8.10.2.11. Morawhanna Village

The community had approximately 100 people in 2019, increasing from 85 in 2018. The community consists mainly of mixed ethnicity. The primary economic activity is fishing by two large boats and about a dozen small boats. There is one primary school (shared with Smith's Creek) that had 88 children in 2018. Students in higher grades attend school in Mabaruma. The area has a major wharf, Guyana Revenue Authority outstation, Coast Guard base, police outstation, and a teachers' accommodation.

In June 2019, the community development council reported that there had been an increase in economic activities within the past few months due to the fuel trade, with boats bringing fuel from Venezuela and selling to local Guyanese dealers. The community has an ice plant and many fishing vessels visit to purchase ice. Locals are capitalizing on the increase in activities by selling of food and beverages to persons engaged in these activities.

Fishing is the major economic activity in the village, with boats from Venezuela visiting the port to purchase fresh fish. Commercial activities are important for livelihoods with food purchased from Mabaruma or at the many local shops. Ocean fishing typically includes two to three trips per month and fish caught includes banga, gillbacker, curass, trout, snapper, snook, etc. There are two fishing boats from the community, and some villagers work on other boats and at the fishing base camp at Waini Mouth. Approximately 15 people continuously conduct crabbing for sale at the Kumaka market and to hucksters on the ferry to Georgetown.

There are no household farms in the area, as flooding is common due to high tides and lack of mangroves and dams. Some persons use traditional plants (noni and fergosa) for medicinal purposes. The area has many species of fish and birds that roost nearby in a few locations. Dolphins used to be sighted in the past but have not been seen recently.

There are no documented cultural or heritage sites in the community despite being the oldest settlement in the area. Traditional religious practices have reportedly ceased. Mangroves are used by people for construction and for building foundation and for firewood. Barks are also harvested for use in tanning. The beach at Waini Point is used for recreational purposes, especially at Easter.

There is a health center but it was not operational in 2019, although repairs to the building were underway. All health matters are referred to Mabaruma Regional Hospital and Hosororo.

Source: ERM/EMC

Figure 8.10-13: Morawhanna Village

8.10.2.12. Smith's Creek Village

The community had 248 people in 2019, increasing from 208 in 2018. The residents are mainly of Warrau descent, with more females than males (60 percent and 40 percent, respectively). There are some Venezuelan migrants within the community, with as many as 80 being present at one time. The primary economic activity is sale of fish followed by manicole palm harvesting and farming. The community is considered part of the Mabaruma Town Council. There is no primary school in the village; in 2018, there were 36 children who attended school at Morawhanna. Students in higher grades attend school at Mabaruma and Hosororo.

Fishing is important to the community for livelihoods, with 3 large boats and 15 small boats fishing on an average of two times per month. Large boat trips are up to 10 days while smaller boats are out 2 to 3 days. Fresh fish is sold at Kumaka market and to Venezuelan trawlers. Typical saltwater species caught include snapper, trout, queriman, curass, gillbacker, and banga. Freshwater fishing is also conducted in the rivers and species caught include curass, gillbacker, and basher. Fish camps by small boats are sometimes set up at the Waini Mouth. Three households have farms and use the lands to cultivate crops where the land is high enough to not flood. The village is easily flooded and thus farmers are discouraged from farming. All community members conduct crabbing during the crab seasons and other persons catch crab year round. As of 2019, a crabmeat processing facility was being established. About 10 to 15 households are engaged in harvesting manicole. A family or crew can harvest 1,500 sticks of manicole palms per trip, making one trip per month.

The area has many species of birds, and curry-curry (scarlet ibis) and gaulins (cattle egrets) roost nearby in a few locations. There are also ducks at the creek head and one villager is involved in trapping in the outlying areas such as Macaw Point and Crab Dog Area. One person is involved in hunting and usually hunts labba, deer, and turtles.

There are no cultural heritage sites in the area and traditional religious practices have reportedly ceased. Medicinal plants including noni and mangroves are collected from the beach. Mangroves are used by persons for construction and for building foundations, firewood, fishing poles, and medicinal uses.

There is no health facility and all health matters are referred to Mabaruma Regional Hospital, although the residents would more easily access the health clinic in Morawhanna Village if it were operational.

Source: ERM/EMC

Figure 8.10-14: Smith's Creek Village

8.10.2.13. Imbotero Village

The community had 353 persons in 2019, increasing from 200 in 2018, and consisting mainly of Warrau descent. As of 2019, there were 153 Venezuelan migrants of Warrau descent within the community who had joined in the prior year. They were given temporary status to live and use the village resources and are being supported by the Government of Guyana through the Civil Defence Commission. The Warraus from Venezuela bring hammocks, dried fish, craft, and household items for sale in the village and at Kumaka.

The primary economic activity is fishing, with manicole palm harvesting in the dry season and farming also important. There is one primary school in the village housing 53 students in 2018. Students in higher grades attend school at Mabaruma and Hosororo. There is a police outpost that serves as a checkpoint since the village is located at the border with Venezuela. The village is facing health challenges due to a scarcity in drinking water and proper toilet facilities.

Fishing is important to the community for livelihoods, with all men and some women involved in fishing for commercial purposes for sale at Kumaka. Sometimes people come to the community to purchase fresh fish, including morocut, curass, gillbacker, houri, yarrow, patwa, and hassar.

Some families/fishing crews harvest manicole palms every month for sale and almost all people conduct crabbing during the crab seasons. Twenty households have farms and use the lands not vulnerable to flooding to cultivate crops. The village is easily flooded, and the dams are consistently destroyed by crabs. Some villagers are involved in trapping but most of the activity is opportunistic during fishing trips to outlying areas such as Macaw Point or Lion Creek. There are numerous jaguars in the area, which have reportedly killed and eaten many of the village hunting dogs. Land and river turtles are caught by persons for food and sold at Kumaka. Other animals hunted include iguanas, deer, wild hogs, agouti, and labba.

There are no cultural heritage sites in the area and traditional religious practices have reportedly ceased. People use medicinal plants, as the village has no health worker. These medicinal plants are collected from the coast and within the community and include mangrove, noni, sweet broom, and wild tobacco. Mangroves are used by persons for various purposes.

There is no health facility and all health matters are referred to Mabaruma or dealt with by using local medicine from herbs. There has been a recent trend of death in children attributed to lack of clean water and sanitary facilities.

Source: ERM/EMC

Figure 8.10-15: Imbotero

8.10.2.14. Almond Beach

This community is located within the SBPA. The community had 51 people in 2018, with many having migrated away due to the erosion of the beach areas. There are more males than females. The primary economic activity is fishing, with all males involved and using three large boats and three small boats. Farming is the next important activity with staples such as cassava being the main food crop and coconuts planted for sale. Copra and coconuts are sold at Kumaka. Miles of coconut farm were washed away in recent years due to erosion with farmers having since relocated away from the area. There is one primary school in the village housing eight students in 2018. Students in higher grades attend school at Mabaruma or Hosororo. The Protected Areas Commission has three buildings in the village to house its workers and other personnel.

Fishing is important to the community for livelihoods, with all men involved in fishing for commercial purposes and household consumption. There are three main families involved in fishing, which is primarily done between Waini Point and Tiger Beach using hook and lines and short nets. Fishing trips are 2 weeks long and usually there are two trips per month using the three small boats. Most of the fish caught are sold at Kumaka. During the rainy seasons, freshwater fish are caught in the swamp behind the beach. Some people catch crabs for the Kumaka market days year-round.

All households have farms and use the lands to cultivate crops where the land is safe from erosion. Farming is conducted mainly during the wet season due to irrigation with cash crops (pumpkin, watermelon, red beans, bora, okra) and cassava being planted. Excess crops are sold at Kumaka. Coconuts are also harvested and sold, although community representatives noted in 2021 that the economic effects of the COVID-19 pandemic have resulted in the loss of coconut export markets, including Trinidad and Tobago.

The area is also used by the Protected Areas Commission for its base and for tourism activities. In 2021, the commission employed three staff, although it has employed up to eight people in past years. Tourists used to visit the area but (as of 2019) this was closed since the buildings that used to support this activity were being relocated due to erosion. However, local visitors from surrounding areas still frequent the beach. Tourism was halted in 2020 and 2021 as a result of the COVID-19 pandemic.

In 2021, beach erosion was still noted to be a concern in the community, attributed to changing weather and rainfall patterns and incidences of severe tides. Erosion was noted to impact farmlands and turtle nesting areas, and has required relocation of some buildings. Some residents of Almond Beach have moved to other areas (e.g., Moruca, Mabaruma) while others are waiting for land allocations in other communities. Waini Point is now a main stopping point for boats, including fisherfolk, fuel traders, and boat repairs. The area has many species of fish, mammals, turtles, iguanas, and birds. No villagers are involved in trapping, but wild animals are hunted for food, including labba, deer, iguanas, agouti, and wild ducks (muscovy). There are numerous jaguars in the area that hunt turtles. Harpy eagles are sometimes sighted within the area and armadillos are also sometimes observed.

Source: ERM/EMC

Figure 8.10-16: Almond Beach

Mangroves (mature trees) are decreasing along the beach due to erosion, but new plants are growing in the lagoon. Previously, burning was conducted to keep the farming areas clear, but this practice has been reduced due to the protected area status. Families used to participate in livestock rearing, including pigs, cows, and goats but there are no livestock at the moment, other than poultry.

There are no documented cultural heritage sites in the area and traditional religious practices have reportedly ceased. Persons make use of medicinal plants, with noni growing abundantly on the beach. Other plants used include red mangrove, buttercup vine, periwinkle flowers, and sweet broom. Some species are used for building materials including the black mangrove, white mangrove, and almond nut tree. Black and red mangroves are also used for fishing poles. Driftwood is used for firewood. Honey is collected occasionally from wild beehives.

There is a health center building but it was not staffed as of 2018. All health matters are referred to Mabaruma or people take local medicine from herbs.

8.10.3. Impact Assessment—Indigenous Peoples

Planned Project activities will not impact Indigenous Peoples (Amerindians) in Guyana. The Project will not involve any direct disturbance of any indigenous communities, or coastal habitats upon which they rely, and the Project's air emissions, discharges to water, and sound generation, all of which will occur approximately 203 kilometers (approximately 126 miles) northeast of the coastline of Georgetown, will not significantly impact their communities or the habitats on which they rely. Project use of the Guyana shorebases and onshore support facilities in Georgetown will have no impact on Indigenous Peoples, as these facilities are well removed from any traditional indigenous communities.

The Project's potential impacts on Indigenous Peoples as a result of an unplanned event, are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

8.10.4. Management Measures—Indigenous Peoples

As there are no potential impacts on Indigenous Peoples as a result of planned Project activities, no mitigation measures are proposed. Table 8.10-4 summarizes the monitoring measures relevant to this receptor.

Table 8.10-4: List of Monitoring Measures

Monitoring Measures
Monitor frequency of engagement with stakeholders, including fisherfolk, coastal communities, vulnerable groups, and indigenous populations.

9. ASSESSMENT AND MITIGATION OF POTENTIAL IMPACTS FROM UNPLANNED EVENTS

9.1. INTRODUCTION

An unplanned event is defined as an event that is not planned to occur as part of the Project (e.g., accidents), but that has the potential to occur. Since such events are not planned, they are evaluated in a different manner from planned events, specifically by evaluating the consequence of a realistic scenario for an unplanned event and taking into consideration the likelihood that the event could occur[1]. Three levels of likelihood are used: unlikely, possible, and likely, as defined in Table 9.1-1.

Table 9.1-1: Levels of Likelihood for an Unplanned Event Impact Assessment

Likelihood	Definition
Unlikely	Considered a rare event, and there is a small likelihood that an event could occur.
Possible	The event has a reasonable chance to occur at some time during normal operating conditions.
Likely	The event is expected to occur during the life of the facility.

As described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, a risk matrix using the likelihood and consequence/severity of the event is used to evaluate the potential significance of unplanned events. The consequence/severity of the unplanned event is measured in terms of the importance/vulnerability/sensitivity of the resource/receptor and the magnitude of the impact (Table 9.1-2).

Table 9.1-2: Risk Rating Matrix for Unplanned Events

		Consequence/Severity		
		Low	Medium	High
Likelihood	Unlikely	Minor	Minor	Moderate
	Possible	Minor	Moderate	Major
	Likely	Moderate	Major	Major

For the purposes of this chapter of the EIA, the following unplanned events are considered as having the potential to occur during the Project life (at least 20 years), should a combination of standard and Project-specific safety controls fail concurrently:

- Hydrocarbon spill (potentially resulting from any of several different unplanned events);
- Marine vessel collision (focused on potential physical damage to other vessels or structures, and/or injuries);

[1] Temporary, non-routine flaring events, associated in part with upsets and maintenance as well as other non-routine and/or unplanned events, are factored into the air impact assessment through the operational life of the Project. See Chapter 2, Description of the Project, and Section 6.1, Air Quality, Climate, and Climate Change, for discussions on strategies integrated in the FPSO design to reduce the frequency and duration of non-routine flaring for upsets and maintenance.

- Offshore discharge of untreated wastewater from the Floating Production, Storage, and Offloading (FPSO) vessel; and
- Onshore vehicular accident.

These potential unplanned events are described in more detail below. Other minor unplanned events (e.g., dropped objects, small spills on deck that do not enter the ocean) have a credible potential to occur, but which would not significantly impact any resources/receptors considered in this EIA. These other unplanned events would occur on the drill ships, installation vessels, supply vessels, or the FPSO, and their impacts would tend to be limited to Project employees and contractors (e.g., a variety of accidents that could result in worker injury, but no measurable impact on natural resources or the public). These events are addressed primarily through EEPGL's and its contractors' health and safety policies and procedures, which are discussed in Chapter 2, Description of the Project; Chapter 11, Environmental and Socioeconomic Management Plan Framework; and the Project's Environmental and Socioeconomic Management Plan (ESMP), but are otherwise beyond the scope of this EIA.

As discussed previously, the Project will use existing shorebases in Georgetown, which are not dedicated to the Project but could experience unplanned events related to Project support. Insofar as construction, permitting, and operation of such facilities would be the responsibility of the owner/operator, including addressing any potential impacts from unplanned events at their facilities. The Consultants have performed the impact assessment for unplanned events on the basis that such events at shorebases are not within the scope of this EIA.

9.1.1. Hydrocarbon Spill

Producing, processing, storing, and offloading crude oil are core Project activities. Additionally, the Project will use marine vessels, aircraft, and processing equipment that use petroleum products for fuel and lubrication. Multiple layers of control are in place with respect to these activities; however, if multiple controls fail, there is the potential for a hydrocarbon oil spill to occur. EEPGL categorizes oil spills into three tiers:

- Tier I—Spill is small, the source of spill is under control, and EEPGL and its contractors would manage the response using local resources;
- Tier II—Spill is moderate, the source can be quickly brought under control, local response equipment is immediately available, and broader response would be managed in a coordinated manner using regional resources as needed; and
- Tier III—Spill is large and/or the source of the spill is not under control, and response would be managed in a coordinated manner with regional and internationally sourced resources.

Hydrocarbons could potentially be released into the environment from crude oil, marine diesel, fuel oil, aviation fuel, lubricating oil, and non-aqueous drilling fluid (NADF) sources. Releases of hydrocarbons could result from a number of different unplanned events. Discussions of the unplanned events considered are provided below.

9.1.1.1. Helicopter Ditching

The Project will involve the use of helicopters to support drilling, installation, production operations, and decommissioning activities. It is estimated that during development drilling and FPSO/Subsea Umbilicals, Risers, and Flowlines (SURF) installation, flights may increase at peak to a total of approximately 20 to 25 round-trip flights per week. During FPSO/SURF production operations, an estimated maximum of five to seven round-trip flights per week will be necessary to support FPSO/SURF production operations and continued development-drilling activities. Flights during the decommissioning stage would likely be similar to those during the FPSO/SURF installation stage.

Although aviation accidents are rare events, there is the potential for a helicopter to ditch at sea. A ditching incident could be the result of a number of factors, which may potentially include loss of power, severe weather, or bird strike. Worker safety-related aspects are addressed primarily through EEPGL's and its contractors' health and safety policies and procedures; therefore, these are not otherwise addressed in this EIA. However, a ditching could potentially result in a spill of aviation fuel or lube oils from the helicopter and related potential localized environmental impacts.

9.1.1.2. Offshore Bunkering

A variety of Project vessels will supply and support drilling, installation, and production operations activities. Fuel transfer from one vessel to another, a process known as bunkering, may be required at certain times to avoid unnecessary vessel refueling trips between the Project Development Area (PDA) and shorebases. A number of potential scenarios could lead to a fuel release during bunkering (e.g., loose hose couplings, hose or connection failure, valves or manifold leaks, etc.). To reduce the possibility and consequence of such a release, EEPGL or the operators involved in offshore bunkering operations will implement a series of fire prevention controls (design-based and operations) in alignment with good international oilfield practice. Multiple automated safety features are designed into drill ships and offshore supply vessels to minimize the risk of such releases (e.g., automated shut-off valves, alarms, etc.) as well as trained operations and maintenance crews. Additionally, all Project vessels will have robust emergency response plans to direct activities in the event that a leak is detected. Any leak would likely be quickly detected and contained via either an automated and/or manual system. Complete loss of the contents of a fuel tank would be a rare event.

9.1.1.3. Offshore Collision between FPSO and Offloading Tanker

During crude oil offloading from the FPSO to a conventional tanker, the offloading tanker must approach at a controlled, safe speed to about 120 meters (approximately 390 feet) of the FPSO. To minimize collision risk during the approach to the FPSO and during offloading, EEPGL will use a Mooring Master on the offloading tanker. The Mooring Master will guide the offloading tanker to the FPSO for offloading, remain on board during offloading, and then guide the offloading tanker away from the FPSO after offloading. Up to three assistance tugs will help position the offloading tanker during the approach to the FPSO to maintain a safe separation distance. During offloading, the tanker will be connected to the FPSO via a hawser (a taut line)

and the tugs will be connected to the tanker via hawser lines to help ensure the offloading tanker maintains a safe distance from the FPSO at all times (see Figure 2.10-1).

Offloading will only occur when weather and sea conditions allow for safe operations. If the environmental conditions prior to the tanker approaching the FPSO are not suitable, the tanker will stand by at a safe distance until conditions are within acceptable limits. If unexpected adverse weather (e.g., a squall) occurs during offloading, the offloading operations will be stopped and the tanker disconnected and moved away from the FPSO until conditions are within approved, safe limits. In the event of a collision during the tanker approach to, or departure from, the FPSO, the risk of a cargo tank breach on either vessel is greatly reduced by the design of the FPSO (double-hull protected on sides) and the tankers (double-hulled), and the fact that the FPSO is stationary and the offloading tanker would be traveling at a very slow maneuvering speed (assisted/pulled back by tugs). Therefore, sufficient collision energy to breach the hulls is not expected, and a spill scenario from a tank breach was therefore not considered in relation to this unplanned event.

9.1.1.4. Nearshore Collision between a Project Supply Vessel and Third-Party Vessel or Structure, or Grounding

These vessels will transit between the Guyana shorebases and the PDA at all stages of the Project. There is a potential for collisions between these vessels and third-party vessels/structures in the Georgetown Harbour / Demerara River area or for the nearshore grounding of a vessel. Such an incident may result from navigation error or a temporary loss of power that affects the ability of a vessel to steer. Fuel oil or lubricating oil spills resulting from an event could potentially cause environmental impacts.

A number of controls will be implemented to prevent these types of vessel incidents from occurring. EEPGL has comprehensive contractor selection guidelines to ensure contractors are qualified and have robust safety, health, and environmental management systems. EEPGL will provide active oversight over its contractors to verify that they are complying with its requirements. Contractors are required to regularly inspect their vessels, which addresses marine safety and maintenance considerations and reduces the risk of a vessel losing power or steering capability. In addition, vessels operating within the Georgetown Harbour or other coastal areas will be required to adhere to speed restrictions and navigation aids.

The Maritime Administration Department (MARAD) has established a rigorous process for permitting all commercial vessels operating within Guyana’s territorial marine waters. The application for this permit requires submission of numerous supporting documents and certifications as assurance that the vessel is equipped with the appropriate safety and navigation equipment, and that the crew is sufficiently trained in its operation to meet international standards for safe navigation and seamanship. The information required to complete this process is standardized under the relevant international treaties administered by the International Maritime Organization (IMO), and will support MARAD in regulating the operation of Project vessels to enhance maritime safety in Guyana’s territorial marine waters.

9.1.1.5. Other Shorebase-Related Events

Spills of hydrocarbons at the shorebases could also occur from the following unplanned events:

- Partial loss of onshore diesel storage tank contents; and
- Hose failure, mechanical failure, or human error during bunkering operations, resulting in a release of fuel to the water.

9.1.1.6. Offshore Collision between Project Vessels or between a Project Vessel and Third-Party Vessel

Other vessel collisions (e.g., collisions between drill ships, installation vessels, or the FPSO and other vessels) are not considered reasonably foreseeable scenarios given the following safety measures that will be put in place:

- MARAD will issue notices to mariners concerning safety at sea and the location of the drill ships, installation vessels, and the FPSO. EEPGL will also communicate major Project vessel movements to commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners. Through a stakeholder engagement process, EEPGL will communicate Project activities, where possible, to those individuals to facilitate their avoidance of Project vessels. Marine safety exclusion zones with a 500-meter (approximately 1,640-foot) radius will be established around the drill ships during drilling operations and around drill centers during well workovers, in accordance with good international oilfield practice. No unauthorized vessels will be allowed to enter these marine safety exclusion zones. Similar marine safety exclusion zones will be established for the major installation vessels.
- A marine safety exclusion zone of 2 nautical miles (3.7 kilometers) will be established around the FPSO. No unauthorized vessels will be allowed to enter this marine safety exclusion zone during offloading.
- EEPGL will use what is known as a Simultaneous Operations procedure to safely manage Project marine vessels performing work in the same vicinity of each other, which will include considerations for avoiding vessel collisions.
- Marine vessels will have industry-proven station-keeping systems (e.g., FPSO mooring system, dynamic position systems on drill ships) to maintain stations in the offshore environment.

9.1.1.7. Drilling- or Installation-Related Spills

Spills of hydrocarbons during drilling could occur from the following unplanned events:

- A failure or leak in a hydraulic hose on a remotely operated vehicle (ROV) or subsea hydraulic power unit (SHPU) during SURF installation, hook-up, or commissioning;[2]
- A failure in containment or breach of fuel storage tank on a drill ship, resulting in a release of fuel;
- A spill of NADF due to a loss of riser contents resulting from an emergency disconnect between the riser and Lower Marine Riser Package connected to the drill ship and the blowout preventer (BOP) (e.g., due to dynamic positioning (DP) station keeping failure);
- A limited loss-of-well-control event with loss of containment (e.g., if the well becomes unbalanced during the drilling process and begins flowing) that is contained within a relatively short period of time (i.e., within a matter of minutes or hours); and
- A larger loss-of-well-control event with loss of containment where a release continues for a longer (i.e., up to a multi-day) period of time while activities are undertaken to bring the well under control.

9.1.1.8. Production-Related Spills

Spills of hydrocarbons during FPSO production operations could occur from the following unplanned events:

- A failure in containment on the FPSO topsides, resulting in a release of crude oil to the deck and/or sea;
- A failure in containment or breach of fuel or chemical storage tank on the deck of the FPSO, resulting in a release of fuel to the deck and/or sea; and
- A failure of an offloading hose during offloading from the FPSO to a conventional offloading tanker, resulting in a release of crude oil into the sea. Hose failures could result from a variety of causes (for example, one known hose failure was caused by puncture by a swordfish), but the specific cause will not change the level of impact or risk associated with this spill event.

9.1.1.9. Summary of Spill Scenarios Considered

Based on the considerations of unplanned events discussed above, a range of potential spill scenarios were considered for the purpose of the EIA. The scenarios considered provide a representation of the different spill volumes, hydrocarbon types, and locations of spills that could reasonably be expected to occur in this type of project. These include the following:

- Spills of fuel at the Guyana shorebases (Georgetown area) into the Demerara River, or at other locations near the coast, which could result from:

[2] During drilling, SURF installation, hook-up, commissioning, and subsequent deep water production operations, there is a critical need for the utilization of key safety systems and components as part of overall risk management programs and protocols that include the use of ROVs and SHPUs. The extensive use of such systems, along with the extreme physical conditions experienced (temperature/pressures) and the added required mobility and dexterity of such equipment, can cause hoses to wear or rub and can on occasion result in a hydraulic hose failure or leak to occur.

  - An onshore spill from fuel storage at a shorebase facility (Scenario 1);
  - An on-water spill of fuel (e.g., during bunkering of a supply vessel; Scenarios 2, 3, and 12); and
  - An on-water spill of fuel resulting from the nearshore collision of a supply vessel with a third-party vessel or structure, or from grounding of a supply vessel (Scenario 4).
- Spills of fuel offshore, which could result from:
  - Releases of marine diesel from a supply vessel (e.g., due to human error or equipment failure) or hydraulic oil from an ROV or SHPU (e.g., due to hydraulic hose failure or leakage) (Scenario 5);
  - Releases of marine diesel from a drill ship or the FPSO (e.g., due to human error or equipment failure; Scenarios 6 and 7);
  - Helicopter ditching into the ocean during transit between the shore and the FPSO or drill ships and resultant loss of fuel to the ocean (Scenario 8); and
  - A minor FPSO or drill ship deck fire and resultant loss of hydrocarbons along with firewater that washes overboard during firefighting (Scenario 9).
- Spills of crude oil during production operations, which could result from:
  - Releases of crude oil from the FPSO topsides (e.g., due to failure of topsides equipment; Scenario 10); and
  - Releases of crude oil during offloading (e.g., resulting from failure of an offloading hose during offloading from the FPSO to the tanker; Scenario 13).
- Spills during development drilling operations, which could result from:
  - Spills of crude oil as a result of loss of well control with loss of containment (Scenarios 11, 14, and 15); and
  - Spills of NADF (e.g., as a result of loss of riser contents after emergency disconnect due to DP station keeping failure; Scenario 16).

Scenario 14 represents a loss-of-well-control scenario, with an estimated discharge rate of 88,728 barrels (14,196 cubic meters [m^3]) of oil per day (BPD); this scenario was developed by EEPGL based on its worldwide experience conducting similar analyses.

EEPGL developed worst-case discharge (WCD) calculations based on the characteristics of the reservoirs to be developed as part of the Project in accordance with the U.S. Bureau of Safety and Environmental Enforcement's (BSEE's) guidelines published in the U.S. Department of Interior BSEE Worst Case Discharge Analysis (Volume I, February 2016). As stated in the BSEE guidelines document, although WCD modeling results "present an extremely dire representation of the potential for contact between the discharged oil and the environment, they do provide a working baseline of datum that will be useful for further analysis" (BSEE 2016).

The U.S. Bureau of Ocean Energy Management (BOEM) defines the WCD as the single highest daily flow rate of liquid hydrocarbon during an uncontrolled wellbore flow event (i.e., the average daily flow rate on the day that the highest rate occurs, under worst-case conditions). The WCD values represent an open well condition in which *no flow restrictions or well control technologies* such as blow out preventers are in operation. The WCD is neither the total volume spilled over the duration of the event, nor the maximum possible flow rate that would result from high-side reservoir parameters. It is a single value for the expected flow rate calculated under worst-case wellbore conditions using expected reservoir properties. The main purpose of a WCD calculation is to support oil spill response planning. The duration of the WCD release is typically 30 days unless shutting in the well with a capping stack or other technology is expected to occur earlier. GSI is the predominant vendor for WCD calculations provided to BSEE in the Gulf of Mexico region.

EEPGL identified two WCD scenarios to characterize a potential Project well-control scenario with loss of containment. These two scenarios were selected in order to characterize uncontrolled wellbore flows for Project reservoirs with varying characteristics. EEPGL contracted with RPS to model two WCD scenarios for the Project. The 88,728 BPD (14,196 m^3) loss-of-well-control scenario is representative of WCD rates during drilling conditions with drill pipe in the well, so this scenario was modeled as the “Most Credible WCD.” EEPGL also selected a 177,157 BPD (28,345 m^3) loss-of-well-control scenario to be modeled as the “Maximum WCD.” Although modeling of the Maximum WCD scenario supports oil spill response planning, the scenario represents an operational condition that is unlikely to be encountered during drilling operations. In a more representative scenario, apart from BOPs on the wellhead, there would be drill string, tubing, and/or other equipment in the wellbore during a loss-of-well-control event, which would partially constrain and restrict flow from the reservoir.

In summary, the following WCDs were selected for modeling a potential Project loss-of-well-control scenario:

- Most Credible WCD—88,728 BPD (14,196 m^3) for 30 days (Scenario 14)
- Maximum WCD—177,157 BPD (28,345 m^3) for 30 days (Scenario 15)

The results of the Maximum WCD serve as the WCD calculation for a well-control scenario with loss of containment in alignment with the United States’ Gulf of Mexico practice.

These results are summarized, together with reasonable assumptions for associated spill volumes, in Table 9.1-3. The representative spill volumes were developed based on industry experience (i.e., what spill volumes have been known to occur) and to correspond to the three tiers of response that would be employed. Scenarios 1 through 13 and 16 were extrapolated from analyses during other similar projects.

Table 9.1-3: Hydrocarbon Spill Scenarios Considered for Impact Assessment

#	Tier	Location	Possible Scenario	Potential Impact [a]
1	I	Shorebase	Onshore spill of less than 10 bbl (1.6 m^3) (e.g., partial loss of diesel storage tank contents)	Contained onshore; no shoreline impact likely
2	II	Shorebase	On-water spill of less than 100 bbl (16 m^3) (e.g., shore to vessel bunkering spill)	Diesel enters Demerara River estuary; possible minor shoreline impact
3	II	Supply vessel at shorebase	On-water release of less than 500 bbl (80 m^3) of diesel (e.g., shore to vessel bunkering)	Diesel enters Demerara River estuary; possible shoreline impact
4	II	Supply vessel at shorebase or nearshore	On-water spill of less than 100 bbl (16 m^3) (e.g., resulting from grounding or collision with a non-Project vessel or structure)	Diesel enters Demerara River estuary or nearshore waters; possible minor shoreline impact
5	I	Drill, supply vessel offshore	Offshore release of less than 10 bbl (1.6 m^3) of marine diesel fuel (e.g., spill during offshore bunkering operations	Hydrocarbons enter Atlantic Ocean, no shoreline impact likely
6	I	Supply vessel or ROV/SHPU offshore	Offshore spill of less than 50 bbl (8 m^3) of fuel or hydraulic oil	Hydrocarbons enter water, creating sheen on the water surface; no shoreline impact likely
7	I	Drill ship or FPSO offshore	Offshore spill of less than 50 bbl (8 m^3) of fuel (e.g., leak or release due to human error or equipment failure)	Contained on deck of vessel or enters offshore Atlantic Ocean; no shoreline impact likely
8	II	Drill ship or FPSO offshore	Offshore spill of less than 250 bbl (40 m^3) of fuel (e.g., leak or release due to human error or equipment failure)	Contained on deck of vessel or enters offshore Atlantic Ocean; no shoreline impact likely
9	I	Helicopter offshore	Offshore spill of less than 50 bbl (8 m^3) of fuel resulting from helicopter ditching and resultant release of fuel tank contents	Enters offshore Atlantic Ocean; no shoreline impact likely
10	I	FPSO offshore	Offshore spill of less than 50 bbl (8 m^3) of fuel resulting from discharge of hydrocarbons along with washover of firewater	Contained on deck of vessel or enters offshore Atlantic Ocean; no shoreline impact likely
11	I	FPSO offshore	Offshore spill of less than 50 bbl (8 m^3) of crude oil from FPSO topsides (e.g., leak or release due to human error or failure of equipment)	Contained on deck of vessel or enters offshore Atlantic Ocean; possible shoreline impact

#	Tier	Location	Possible Scenario	Potential Impact [a]
12	II	Drill ship/well offshore	Loss-of-well-control release of less than 250 bbl (40 m^3) (e.g., well becomes unbalanced during the drilling process and begins flowing at a low rate prior to containment)	Hydrocarbons enter Atlantic Ocean; no shoreline impact likely
13	II	FPSO, offloading tanker offshore	Offshore release of 2,500 bbl (400 m^3) of oil (e.g., failure of offloading hose during offloading from FPSO to tanker)	Oil enters Atlantic Ocean; possible shoreline impact
14	III	Drill ship/well offshore	Offshore release of oil from loss-of-well-control event (30-day duration at 88,728 BPD [14,196 m^3]) (Most Credible WCD)	Oil enters Atlantic Ocean; possible shoreline impact
15	III	Drill ship/well offshore	Offshore release of oil from loss-of-well-control event (30-day duration at initial rate of 177,157 BPD [28,345 m^3]) (Maximum WCD)	Oil enters Atlantic Ocean; possible shoreline impact
16	II	Drill ship/well offshore	Offshore release of approximately 2,200 bbl (352 m^3) of NADF due to loss of riser contents after emergency disconnect due to DP station keeping failure	NADF enters water near the seafloor; no shoreline impact likely

bbl = barrels
[a] Potential impact is based on modeling of an **unmitigated** spill scenario (see Oil Spill Response Plan in Volume III for further discussion of Scenarios other than 12 and 13).

Oil spill modeling for this EIA focused on higher-volume releases (Scenarios 14 and 15) in which an active response is anticipated. Oil spill modeling serves several purposes: (1) it indicates where the spilled oil is located; (2) it predicts where the oil is going, e.g., trajectory; (3) it provides information on when the oil will get there, e.g., timing; and (4) it predicts whether it will be in recoverable quantities, e.g., fate and mass balance.

Hydrocarbon releases of less than 100 barrels (bbl) (Scenarios 1, 2, 4, 5, 6, 8, 9, and 10) would be expected to quickly be brought under control, and would be managed with locally available spill control equipment.

With respect to the potential for a hydraulic oil release under Scenario 5, some of the management and mitigation measures employed to prevent such a release include:

- Use of such equipment only within the specified weather limitations (required sea states);
- Use of hoses wrapped in anti-chafe spiral wrap when configurations allow;
- Design of such equipment with monitoring systems with the capability of stopping and isolating a release within minutes;

- Pre- and post-dive checks with visual inspections;
- Continued focus on any components under pressure during each pre-deployment check to verify the integrity of all hydraulic systems and associated hosing/connections;
- Preventive maintenance and proactive replacement of hoses in advance of manufacturer's recommended practices due to the depths and harsh conditions in which such equipment is operated;
- Training of crews, which includes hazard identification and a focus on spill prevention; and
- Use of environmentally friendly, highly refined mineral oil–based hydraulic fluids.

Several of the scenarios (7, 9, and 10) are contained on the deck of the vessel and are not expected to enter the ocean, so were not modeled. The diesel fuel releases into the Demerara River represent a release of non-persistent fuel material and were not modeled. These releases are known to be transient with a short duration in this river environment. These diesel spills would not represent an active response beyond possible diversion booming, depending upon the season and species of animals in the area. The focus of Scenario 8 would be the safety, rescue, and recovery of the helicopter crew. The helicopter fuel volume is quite small and this hydrocarbon is not persistent in the environment. Considering the known transient nature of this fuel in the environment, no modeling was performed and no spill response is anticipated. A temporary, visible sheen on the water surface may occur, water quality would be temporarily impaired in a localized area, and sensitive receptors (e.g., plankton and possibly some seabirds or shorebirds) may be locally affected. However, there is not considered to be potential for any long-term or ecosystem-level impacts on ecologically important or protected species. Although the volume of a spill during bunkering in Scenario 12 may be higher than the helicopter fuel volume, marine diesel is generally not persistent in the environment and would rapidly disperse due to the velocity of the currents in the PDA. Impacts on water quality and sensitive biological receptors would be transitory. These spills are, therefore, not considered further in the assessment of risks from potential hydrocarbon spills.

A hydrocarbon release under Scenario 16 would involve a spill of approximately 2,200 bbl (352 m^3) of NADF into the ocean near the seafloor. Under this scenario, the spill would be limited to the capacity of the drilling riser. The potential impacts of a release of this nature would primarily occur at or near the seabed, and may include localized smothering and toxicity that would affect benthic species, although this disturbance would occur in the same area where disturbance from drilling and cuttings discharges have already occurred. Any dispersion of the NADF would also result in localized impacts on water quality and sensitive planktonic or fish species. Other than a localized area where the material has deposited, any water quality or other impacts would be short-term, as the product would disperse within the water column and be carried away by currents.

A hydrocarbon release under Scenario 3 would involve a spill of approximately 500 bbl (80 m^3) of diesel into an adjacent river or water body where a shorebase is located. Due to the rapid natural dispersion and evaporation of diesel, combined with dilution by water movement and

tidal exchange, impacts would be limited in duration and would reduce with distance from the spill site.

Hydrocarbon releases under Scenario 11 (minor loss-of-well-control release during drilling), Scenario 13 (release during offloading from FPSO to tanker), and 14 and 15 (a larger loss-of-well-control incident) would all involve a crude oil spill in the PDA, requiring the implementation of both local and regional response resources as well as Oil Spill Response Limited's global oil spill technical response teams and equipment. Oil spill modeling for the larger release scenarios (Scenarios 14 and 15) and coastal sensitivity mapping have been conducted to identify and characterize the resources/receptors with the potential to be exposed to spilled oil from these types of events. An overview of the modeling approach and results for Scenarios 14 and 15 are provided in Section 9.1.4, Oil Spill Modeling Overview, and Section 9.1.5, Oil Spill Modeling Results. The potential risks associated with the smaller volume offshore oil spills are encompassed within the modeling.

It should be noted, however, that a hydrocarbon spill of any material amount is considered unlikely primarily because of controls EEPGL and its contractors put in place to prevent a spill from occurring. Section 2.14, Embedded Controls, provides a description of the embedded controls related to spill prevention; further detail is provided in Section 9.1.7, Oil Spill Prevention, Control, and Emergency Response Measures.

Despite the unlikely probability of an oil spill, the resource-specific impact assessments consider, as appropriate to the resource, potential impacts associated with three categories of oil spill scenarios:

- Coastal fuel spill—consisting of onshore and on-water spills (Scenarios 1 through 4), with onshore spills represented by Scenario 1 and on-water spills represented by Scenario 3, the largest of the nearshore spill scenarios. The onshore spill scenario assumes a less than 10 bbl (1.6 m^3) spill from the partial loss of diesel storage tank contents that is contained onshore, while the on-water/nearshore scenario assumes an on-water release of less than 500 bbl (80 m^3) of diesel entering the Demerara River estuary with possible shoreline impact.
- Marine oil spill—represented by offshore spills (Scenarios 5 through 15), with Scenarios 14 and 15 chosen to represent worst cases. These scenarios assume a release of oil from a loss-of-well-control event to the Atlantic Ocean with a possible shoreline impact. Scenario 14 represents the Most Credible WCD (30-day duration at 88,728 BPD [14,196 m^3]), while Scenario 15 represents the Maximum WCD (30-day duration at initial rate of 177,157 BPD [28,345 m^3]).
- NADF release—represented by Scenario 16, which assumes approximately 2,200 bbl (352 m^3) of NADF entering the water near the seafloor due to the loss of riser contents with no shoreline impact likely.

9.1.2. Factors Impacting Severity of Hydrocarbon Spills

Several factors impact the severity of hydrocarbon spills and the efficacy of available spill response options. These factors include the hydrocarbon properties, volume and location of the spill, metocean conditions, and seasonal factors impacting the presence of wildlife (Dicks 1998).

Hydrocarbon products vary widely in their physical and chemical properties, as well as their potential impacts on marine organisms (Figure 9.1-1). Heavy oils have the potential to cause more significant and longer-term impacts, as they may persist along shorelines and cause smothering of intertidal plants and coral reef habitats. In contrast, light oils tend to be more toxic, but dissipate much more quickly through evaporation and dispersion, so they generally have less impact overall and their potential toxic impacts are likely to be localized and short-lived (ITOPF 2014; Dicks 1998).

Source: ITOPF 2014

Figure 9.1-1: Typical Impacts on Marine Organisms across a Range of Oil Classes

The oil that will be produced from the Yellowtail and Redtail fields is categorized as a “medium crude” oil with a specific gravity less than that of water. For a release near the top of the water column, the majority of this oil would rise quickly to the water surface. For a release near the seabed, the oil would rise and the plume containing the oil droplets and gas bubbles would entrain seawater as it moves upward in the water column. In the PDA, the water depth is sufficient to cause these plumes to terminate (i.e., “trap”) within the water column. Once the plume traps, the oil droplets would rise only through buoyancy until they reach the surface or dissolve, with the rise rate of the oil droplets varying depending on the droplet size (i.e., with larger droplets rising faster than small) (RPS 2019). As a result, the potential for persistent slicks, shoreline impacts, and smothering is reduced relative to heavy crude or heavy fuel oil products.

The Project will use low-toxicity NADF in its drilling operations, which is denser than the medium crude oil in the Yellowtail and Redtail fields and contains specific weighting materials used during the drilling process. As such, the NADF would tend to remain near the seafloor if released from the bottom of the riser (e.g., during an emergency disconnect scenario).

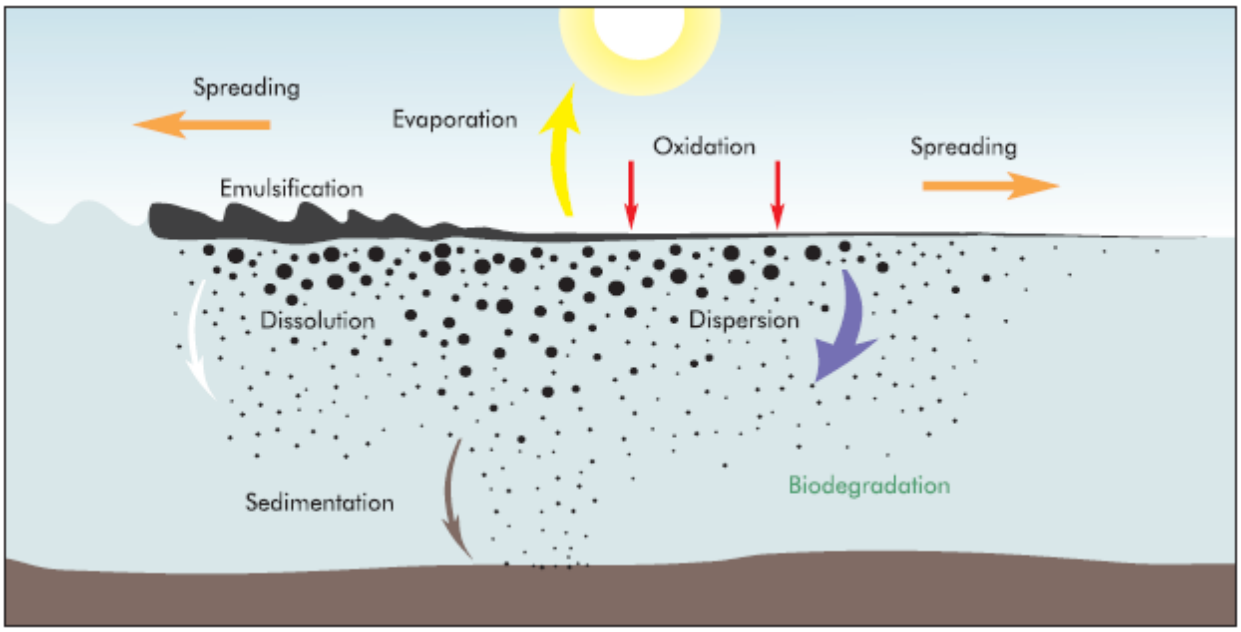
Events involving the loss-of-well-control considered for the purpose of this EIA would occur in the ocean approximately 203 kilometers (approximately 126 miles) northeast of the Georgetown coastline. The open waters of the ocean, and associated pelagic and seabed communities, are typically more resilient to spills than shoreline environments (Dicks 1998).

Climate and weather can also impact the behavior of an oil spill. For example, oils become more viscous (i.e., flow less readily) at lower sea surface and air temperatures. In this case, the surface waters in the Project Area of Influence (AOI) are relatively warm, typically ranging from

24 to 30 degrees Celsius (°C), which would result in the oil remaining fluid, enhance evaporation of the lighter fractions (as discussed below), and improve spill response options such as dispersant application and *in situ* burning.

9.1.3. Weathering Process

As soon as hydrocarbons are introduced into the ocean, advection and spreading begin immediately and result in a rapid increase of environmental exposure to hydrocarbons and their subsequent "weathering" processes (Figure 9.1-2). These processes include evaporation, dissolution, vertical dispersion, emulsification, and sedimentation. All of these processes are influenced by the specific composition of the introduced hydrocarbon. In addition, some components are degraded by photochemical oxidation induced by sunlight.



Source: ITOPF 2013

Figure 9.1-2: Weathering Processes Acting on Hydrocarbons in an Ocean Environment

These processes may result in vaporized hydrocarbon fractions and reaction products in the atmosphere, slicks and tar lumps on the ocean surface, dissolved and particulate hydrocarbon materials in the water column, and particulate fractions in the sediments. While physical and chemical weathering processes are occurring, biological processes such as biodegradation and bioaccumulation can also act on the hydrocarbons. Biodegradation involves the chemical breakdown of hydrocarbons to metabolites and ultimately to carbon dioxide, while bioaccumulation involves chemical uptake by larger organisms and the subsequent metabolism, storage, or discharge of the chemical.

Although some of these processes (e.g., photochemical oxidation, evaporation) would not occur at the depths at which an NADF release could occur, the NADF would be subject to biological degradation. Biological degradation proceeds more slowly under anoxic conditions than under

well-oxygenated conditions, so biological degradation would tend to occur most rapidly where the NADF is thinly distributed over a wide area of seafloor rather than in thicker clumps over a small area that may penetrate into anoxic sediment and promote unfavorable biodegradation conditions by decreasing microbial access to oxygen.

9.1.4. Oil Spill Modeling Overview

Oil spill models have been in use for more than 30 years to support the development of oil spill response planning. Trajectory and fate models simulate oil transport and predict the changes the oil undergoes (i.e., its fate) as it interacts with water, air, and land. The models simulate spill events based on a characterization of the wind and hydrodynamic (marine currents) forces that influence oil transport. The model uses current data directly as surface oil moves with the speed and direction of the current. Wind data affect oil slicks at a range of 1 to 5 percent. Therefore, the SIMAP Model (RPS 2018b) estimated the wind drift to be 3.5 percent of wind speed. The model combines the magnitude and direction of the wind and current data inputs. The resulting predictions from the models can be used to quantify the potential consequences of a spill, which can then be used to guide response planning and prioritize response asset deployment. There are two principal modes in which oil spill models can be used:

1. **Stochastic** (statistical) mode, which examines *many potential releases* from the same point using the full range of historical data for wind and currents; and
2. **Deterministic** mode, which examines a *single potential release* using specific historical wind and hydrodynamic data selected from a range of historical data, or using forecasted wind and hydrodynamic data for an ongoing or future event.

Extreme weather events typically are considered qualitatively in oil spill modeling. The PDA is not in a seismically active area, so seismic events such as tsunamis did not factor into oil spill modeling. The Project infrastructure is designed to withstand other potential extreme events (e.g., squalls); in fact, these extreme events have little to no effect on the wells, which are located approximately 1,700 to 1,900 meters (5,577 to 6,233 feet) below the ocean surface. In any case, weather forecasts would provide advance notice of these events and would enable EEPGL to take appropriate operational precautions to reduce the chance of an oil spill under such conditions. Accordingly, the oil spill modeling conducted for the purpose of this EIA was based on historical environmental (wind, wave, and current) and hydrodynamic data.

A typical approach to using oil spill models in oil spill response planning is to first apply the stochastic mode to determine the most likely trajectory for the spill scenarios of interest. The stochastic approach captures variability in the trajectory by simulating hundreds of individual spills (i.e., under different environmental [wind, wave, and current] and hydrodynamic conditions) and generating a map that is a composite of all of the predicted trajectories, thus providing a *probability footprint* showing the most likely path for a given spill scenario. Spill scenarios are typically modeled in stochastic mode to estimate probability that a specific area would be impacted by the spill, and timing of arrival of the spill at a particular area for each season or wind regime in the region.

Each stochastic model run results in a map showing the probability of a specified thickness of oil on the sea surface across the study area, and the minimum time of oil arrival across the study area. Examples of stochastic maps are shown in Section 9.1.5, Oil Spill Modeling Results.

The specified thickness threshold on which the probabilities are based is chosen based on the purpose of the modeling or the types of impacts being considered, including ecological and socioeconomic impacts. Modeling is then used to determine the probability that oil would be present at a location in a thickness at or exceeding the designated threshold. For example, a surface slick thickness threshold can be based on the minimum thickness that can be mechanically recovered or on the minimum thickness that is thought to cause ecological or socioeconomic impacts. When applied in this way, a trajectory and fate model can quantify the likelihood of specific spill consequences, which is supportive of spill response planning and preparedness and environmental impact analysis.

Surface oil thickness thresholds are typically expressed in units of mass per unit area (e.g., grams per square meter [g/m^2]). Table 9.1-4 summarizes the range of thicknesses relative to their appearance on water.

Table 9.1-4: Oil Thicknesses (g/m^2) and Appearance on Water

Code	Description	Layer Thickness Interval (g/m^2)	Liters per Square Kilometer
1	Sheen	0.04–0.3	40–300
2	Rainbow	0.3–5.0	400–5,000
3	Metallic	5.0–50	5,000–50,000
4	Discontinuous True Oil Color	50–200	50,000–200,000
5	Continuous True Oil Color	200 +	200,000 +

Source: Bonn Agreement 2007

For the purpose of this EIA and oil spill response planning, a threshold of 1.0 g/m^2 has been used for modeling spills. This represents an oil thickness where ecological effects on very sensitive species may potentially occur and select spill response and recovery methods could be applied in suitable circumstances (e.g., wind and sea state).

Oil spill modeling in the deterministic mode is used to predict where spilled oil from a single release would go and how quickly it would arrive at given locations. The trajectory of the spill is determined by the specific modeled wind and hydrodynamic conditions. The model predicts the spill pathway by calculating the movement of the oil for individual short increments of time, e.g., 1 hour, over the spill's duration, which cumulatively results in what is known as the *spill trajectory*. Knowing the distance traveled by the oil over a period of time also provides a prediction of the time of travel for the spill to reach specific areas. Consequences from the spill are determined by running the model within a geospatial framework so that interactions between the oil and elements of the environment (e.g., habitats) can be considered. Given an adequate definition of currents, winds, and the environment, a deterministic model can provide comprehensive predictions of the trajectory, fate, and effects of the oil.

Oil spill trajectory and fate models provide a quantifiable and consistent means to quantify spill consequences. A trajectory and fate model can also simulate the effects of spill response activities such as mechanical recovery, dispersant application, and *in situ* burning. Model simulations with and without spill mitigation measures are used to calculate the effectiveness of different response strategies and equipment and can be used to help validate and improve spill response plans and contribute to a Net Environmental Benefit Analysis (NEBA) process. The NEBA process examines the benefit of using various spill response technologies against the effect of the oil spill itself prior to deploying the preferred technologies in a spill event.

Once individual spill events have been defined based on the selected criteria, a deterministic map for each event, showing the predicted trajectory and fate of the spilled oil, is generated. These deterministic maps can be generated for a range of spill scenarios and included in an Oil Spill Response Plan (OSRP) for use in planning responses to different scenarios. Examples of deterministic maps are shown in Section 9.1.5, Oil Spill Modeling Results.

9.1.5. Oil Spill Modeling Results

From the list of oil spill scenarios described in Section 9.1.1, Hydrocarbon Spill, oil spill modeling results are presented in this section for Scenarios 14 and 15 (the marine oil spill scenarios with the largest release volumes). Modeling results for additional (smaller release volume) scenarios are included in the OSRP. Scenarios 14 and 15 are 30-day, loss-of-well-control events, with oil released to the ocean from near the seafloor at rates of 88,728 barrels per day (BPD) (14,196 m^3 per day) for the Most Credible WCD and 177,157 BPD (28,345 m^3; initial release rate) for the Maximum WCD.

The initial deterministic model runs for each scenario predict potential impacts in the absence of spill response measures, a baseline that response activities may be measured against. Subsequently, additional deterministic model runs were conducted with the implementation of response measures, which significantly reduces the severity and extent of a spill and its impacts, as demonstrated by the modeling.

Spills originating near the seafloor were simulated using the OILMAP Deep model (RPS 2018a; RPS 2021) to predict the discharge plume geometry, droplet size distribution discharged into the water column, and fate of the oil plume. The SIMAP model system (RPS 2018b; RPS 2021) was used to predict the probability of oil reaching 1 g/m^2 thickness on the sea surface across the study area, taking into account the weathering profile of the oil (which would result in a proportion of the oil evaporating or dispersing into the water column). Spills were simulated taking into consideration the quantity of oil released, the type of oil and its characteristics (e.g., density), historical seasonal wind and current patterns, and water depth, among other factors.

For each of these scenarios, modeling was performed for the Jun–Nov season, as well as the Dec–May season. The results are described below, including modeling under stochastic, deterministic (i.e., unmitigated), and deterministic-with-response (i.e., mitigated) modes.

9.1.5.1. Scenario 13—FPSO Release of 2,500 Barrels of Crude Oil

Information for the modeling of Scenario 13 was produced using the oil spill modeling results for the Payara PDA (RPS 2018a) as a proxy for Yellowtail. Use of the Payara results as a proxy for the Project under this scenario is appropriate given the similarity of input conditions leading to similar modeling outcomes. Further, oil spill prevention, control, and emergency response measures designed to address much larger spills, such as those modeled for the Payara PDA, would be sufficient to address the comparatively small spill under this scenario (see Section 9.1.7, Oil spill Prevention, Control, and Emergency Response Measures).

Figure 9.1-3a shows a stochastic map for sea surface oiling (without mitigation by response activities) resulting from Scenario 13 (a 2,500 bbl (400 m^3) surface spill originating from the Payara FPSO location) in the Jun–Nov season. The top panel shows the probability of sea surface oiling above a minimum thickness of 1.0 g/m^2, and the bottom panel shows the minimum amount of time for sea surface oiling above a minimum thickness of 1.0 g/m^2. Figure 9.1-3b shows the same stochastic map, zoomed in.

Figures 9.1-4a and 9.1-4b show the stochastic maps for sea surface oiling (without mitigation by response activities) resulting from Scenario 13 in the Dec–May season.

Figure 9.1-5a shows a deterministic map (without mitigation by response activities) resulting from Scenario 13 in the Jun–Nov season. The dark blue area shows the “swept area,” which is the aggregated area that the model predicts the unmitigated oil spill will have traveled across by the end of the 10-day modeling simulation. The black areas show the oil predicted to be remaining on the surface above a minimum thickness of 1.0 g/m^2 at the end of the 10-day modeling simulation. The red areas indicate where oil is predicted to have made shoreline contact above a minimum thickness of 1.0 g/m^2 at the end of the 10-day modeling simulation. Figure 9.1-5b shows the same deterministic map zoomed in on the Guyanese coast.

Figures 9.1-6a and 9.1-6b show the deterministic maps (without mitigation by response activities) resulting from Scenario 13 in the Dec–May season.

Figures 9.1-7a and 9.1-7b show the deterministic maps (with mitigation by response activities) resulting from Scenario 13 in the Jun–Nov season. Figures 9.1-8a and 9.1-8b shows the deterministic maps (with mitigation by response activities) resulting from Scenario 13 in the Dec–May season. As shown by the modeling results, with the application of spill response measures, the modeling predicts a significantly reduced extent of surface movement of the spill and no impacts on any coastlines.

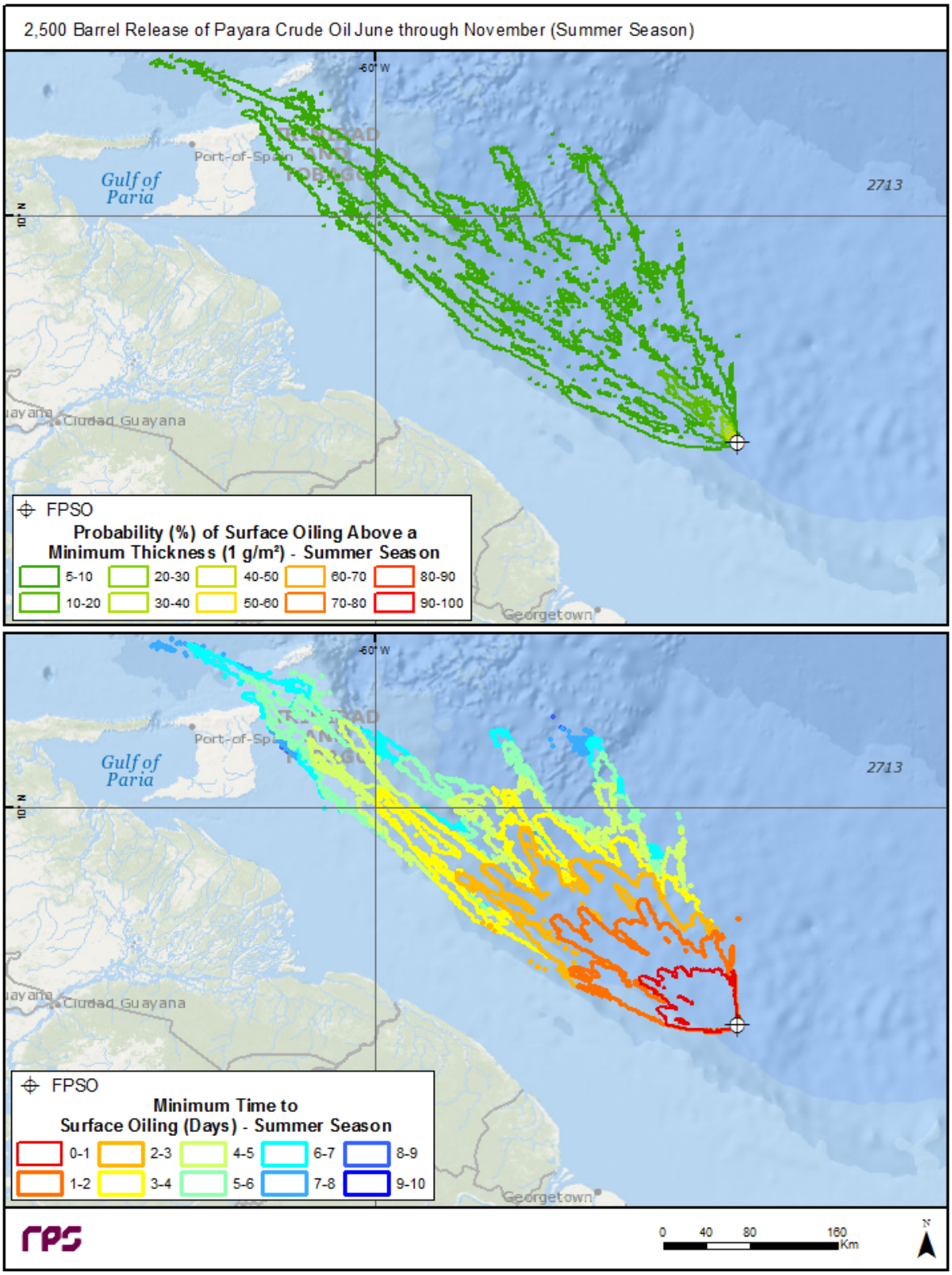


Figure 9.1-3a: Proxy Stochastic Map for Scenario 13—Predicted Surface Oiling and Timing from an Unmitigated 2,500-Barrel (400 m^3) Surface Release of Crude Oil (Jun–Nov)

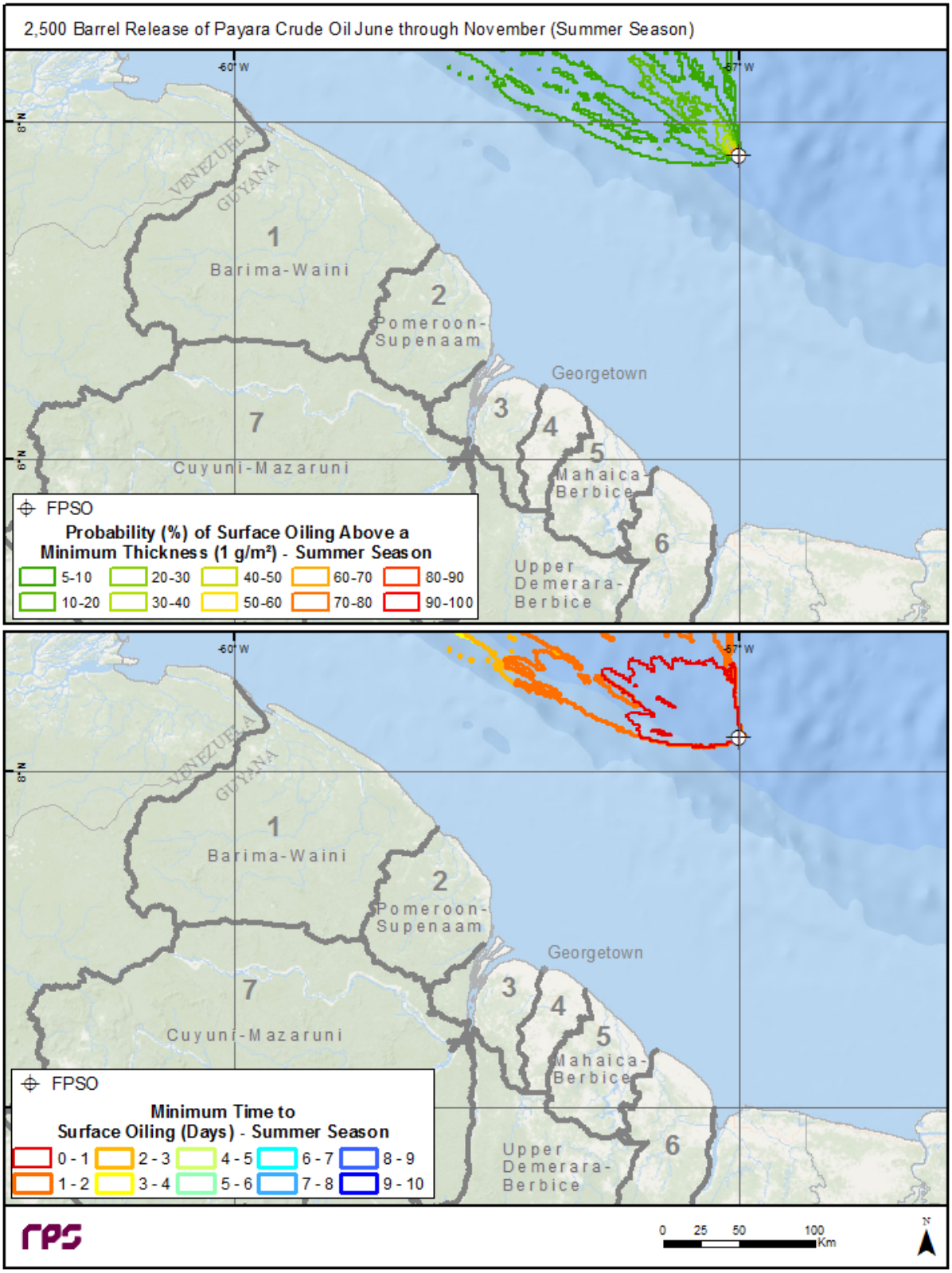


Figure 9.1-3b: Proxy (Zoomed In) Stochastic Map for Scenario 13—Predicted Surface Oiling and Timing from an Unmitigated 2,500-Barrel (400 m^3) Surface Release of Crude Oil (Jun–Nov)

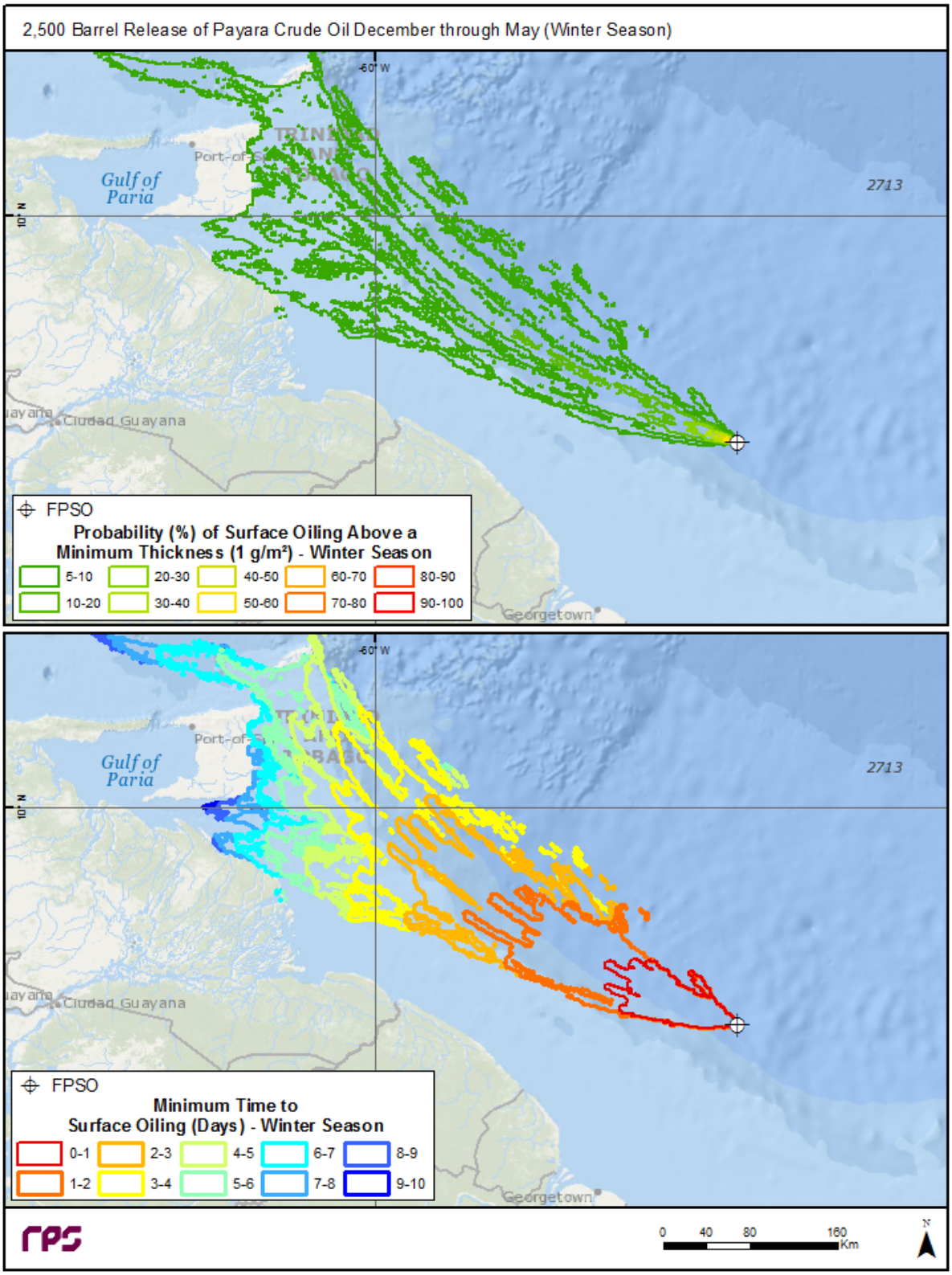


Figure 9.1-4a: Proxy Stochastic Map for Scenario 13—Predicted Surface Oiling and Timing from an Unmitigated 2,500-Barrel (400 m^3) Surface Release of Crude Oil (Dec–May)

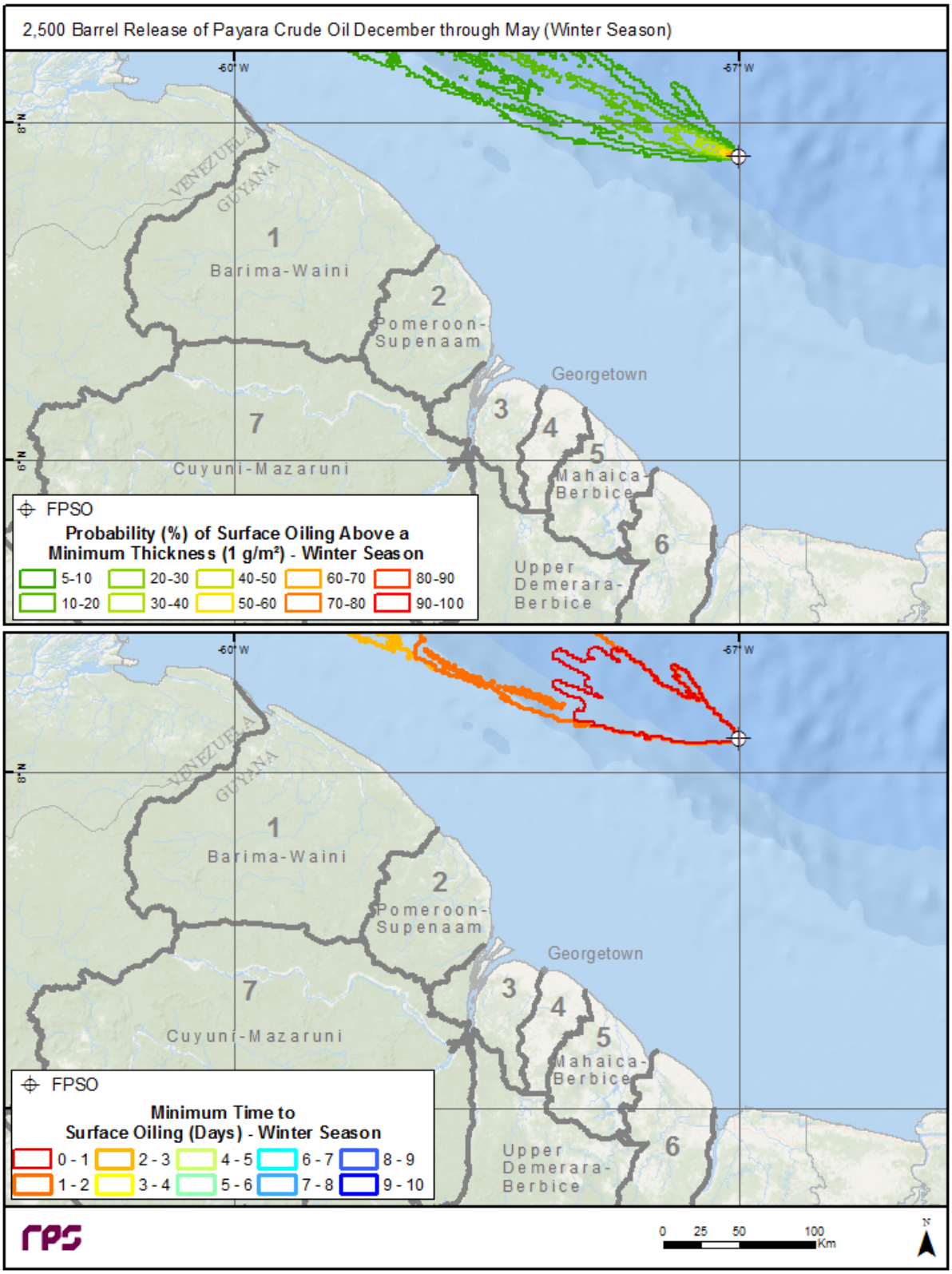


Figure 9.1-4b: (Zoomed In) Proxy Stochastic Map for Scenario 13—Predicted Surface Oiling and Timing from an Unmitigated 2,500-Barrel (400 m^3) Surface Release of Crude Oil (Dec–May)

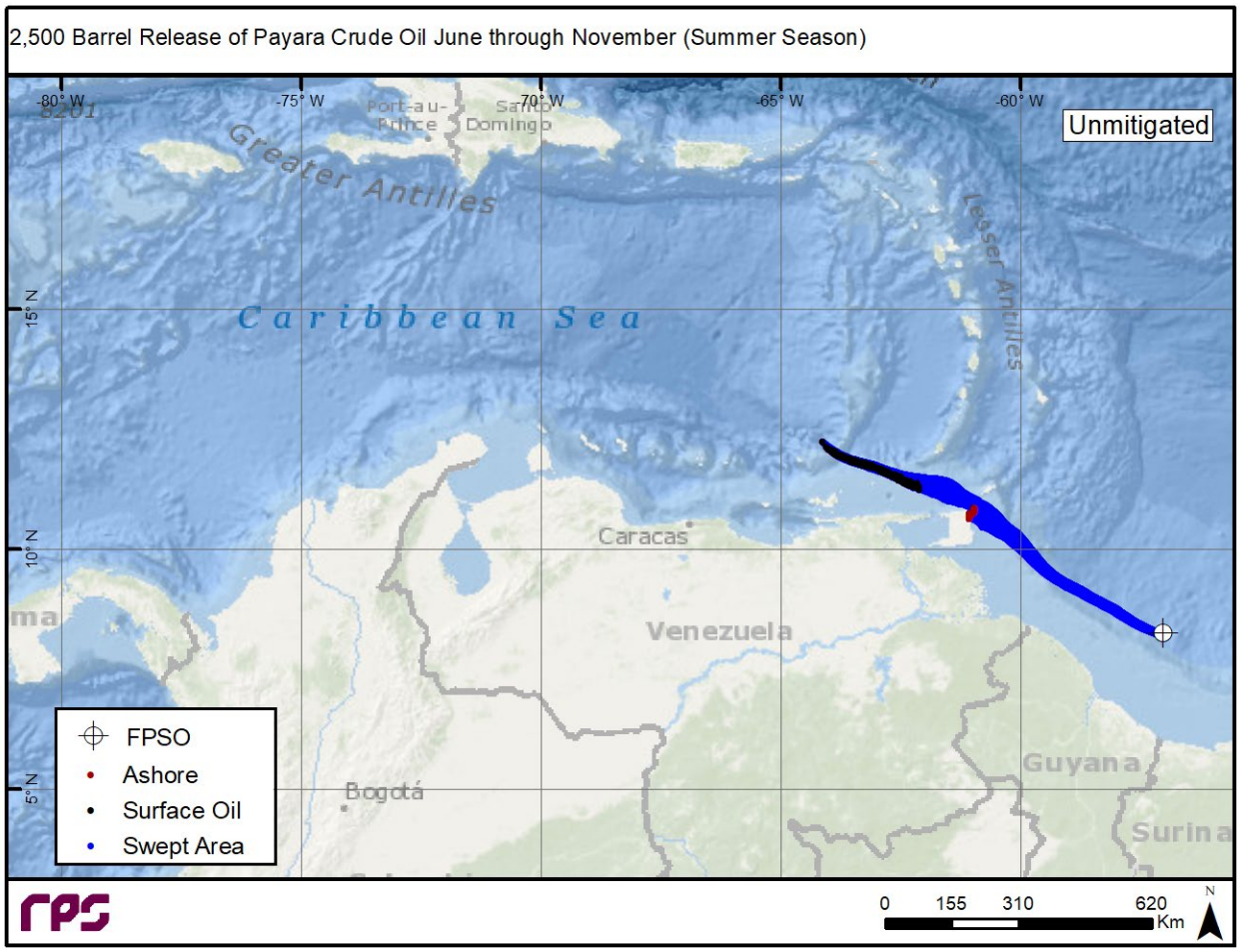


Figure 9.1-5a: Proxy Deterministic Map for Scenario 13—Predicted Transport after 10 Days from an Unmitigated 2,500-Barrel (400 m^3) Surface Release of Crude Oil (Jun–Nov)

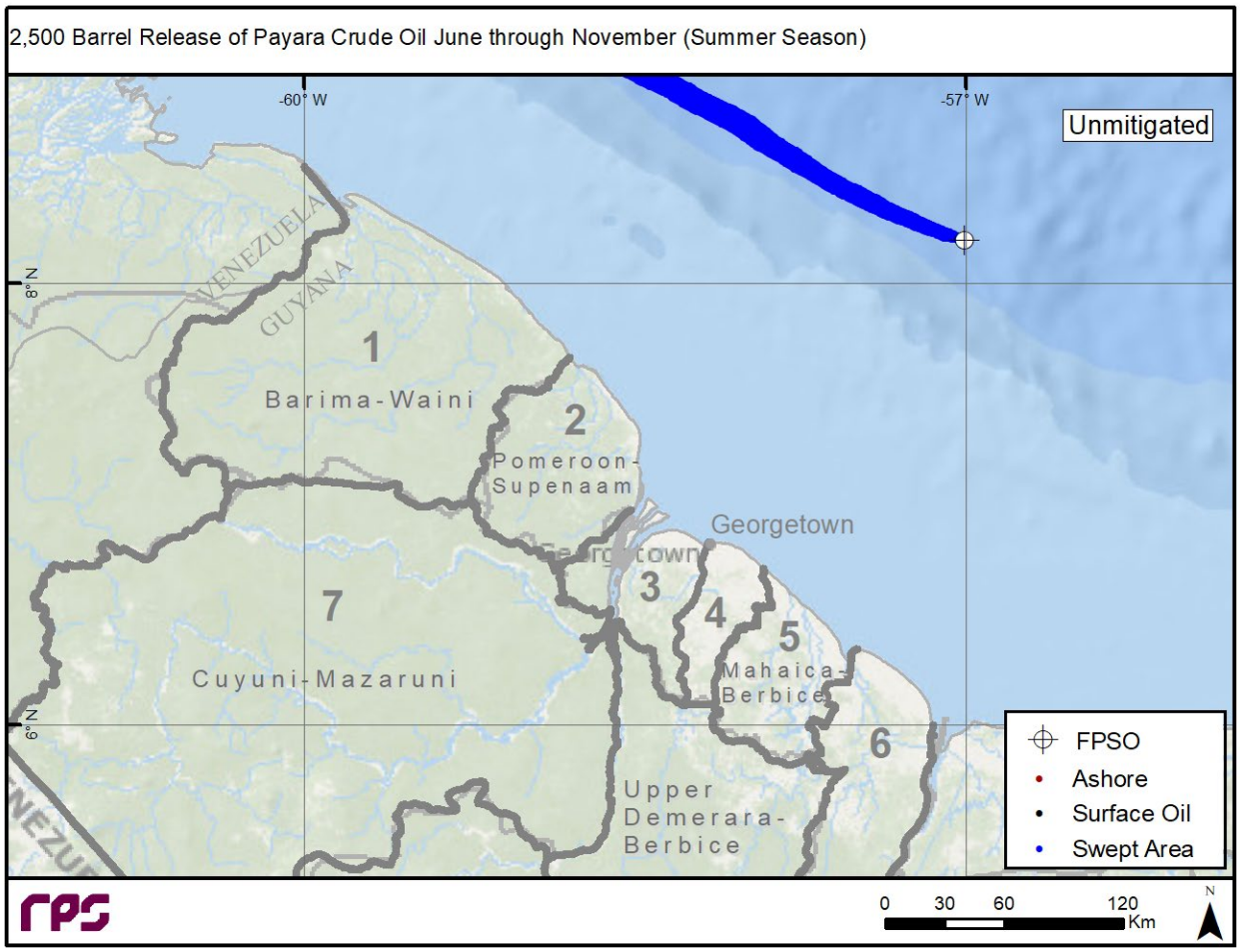


Figure 9.1-5b: (Zoomed in) Proxy Deterministic Map for Scenario 13—Predicted Transport after 10 Days from an Unmitigated 2,500-Barrel (400 m^3) Surface Release of Crude Oil (Jun–Nov)

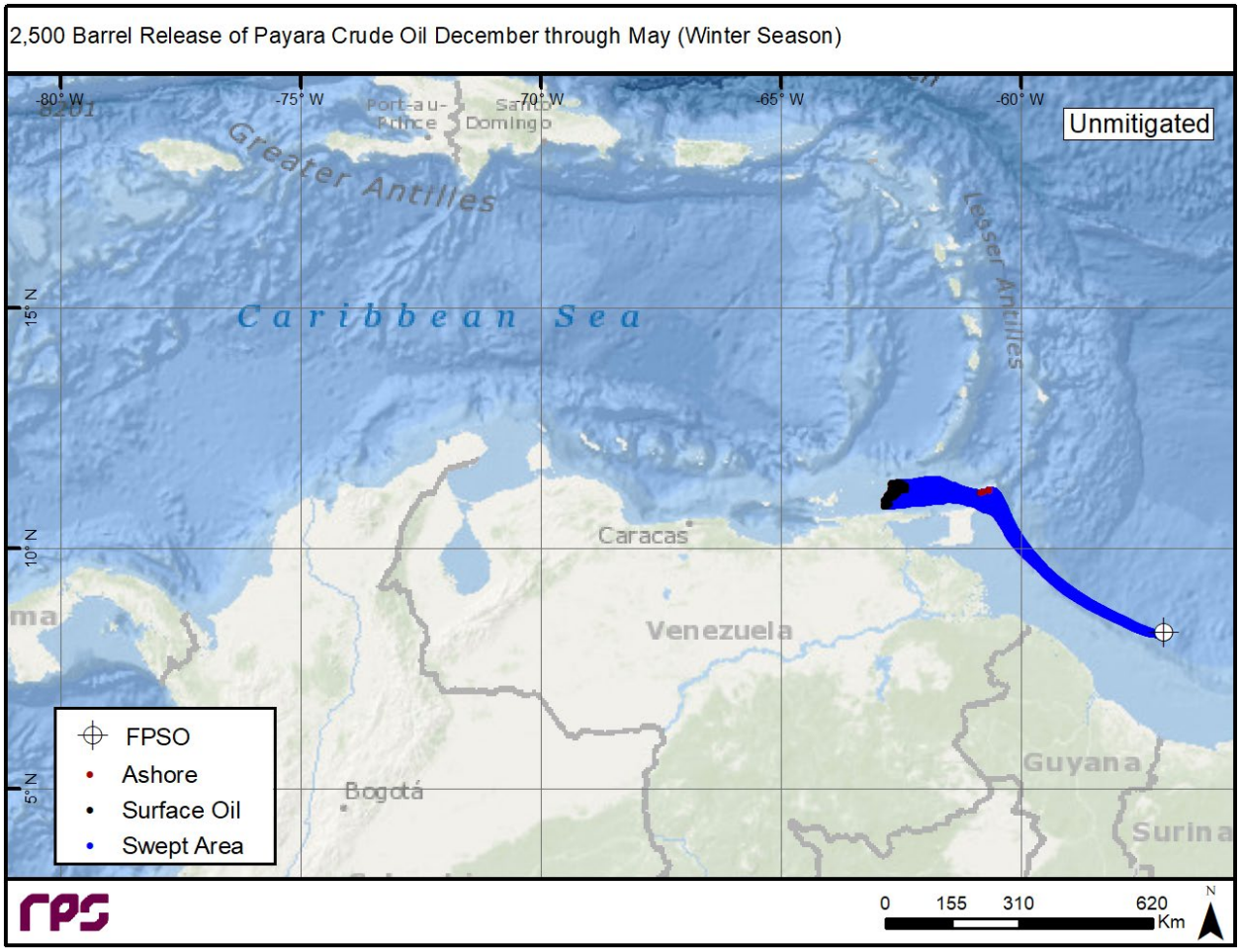


Figure 9.1-6a: Proxy Deterministic Map for Scenario 13—Predicted Transport after 10 Days from an Unmitigated 2,500-Barrel (400 m^3) Surface Release of Crude Oil (Dec–May)

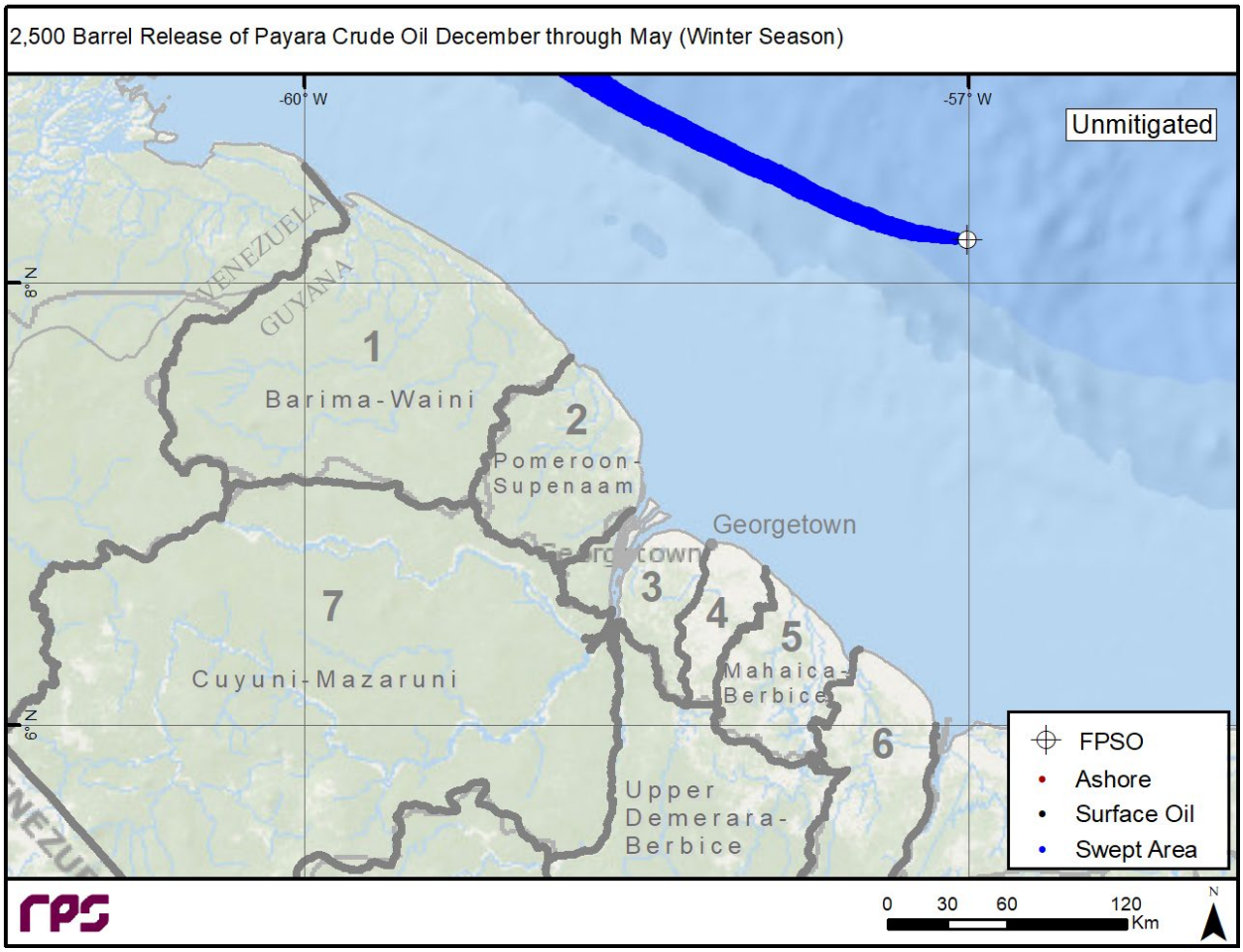


Figure 9.1-6b: (Zoomed in) Proxy Deterministic Map for Scenario 13—Predicted Transport after 10 Days from an Unmitigated 2,500-Barrel (400 m^3) Surface Release of Crude Oil (Dec–May)

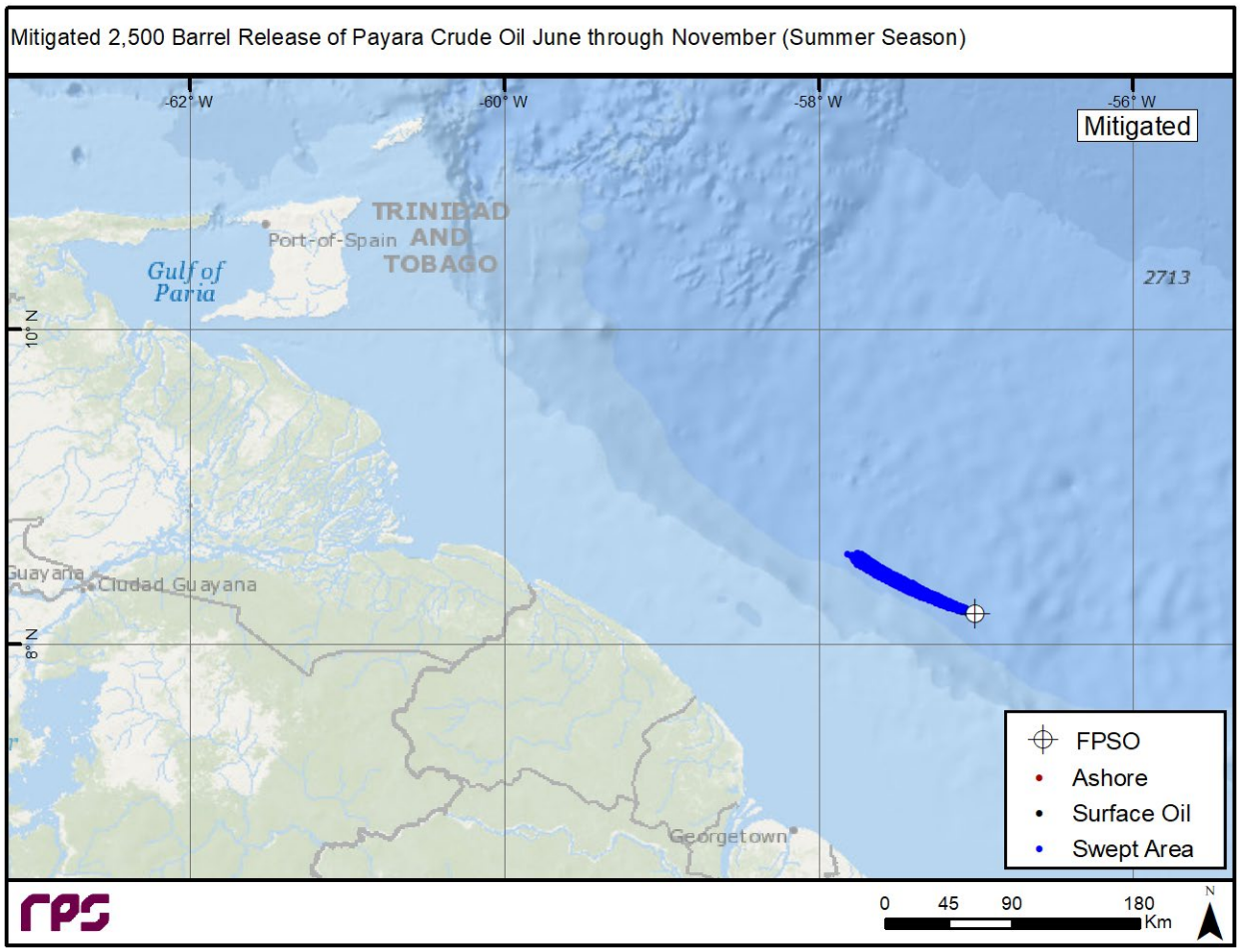


Figure 9.1-7a: Proxy Deterministic Map for Scenario 13—Predicted Transport after 10 Days from a Mitigated 2,500-Barrel (400 m^3) Surface Release of Crude Oil (Jun–Nov)

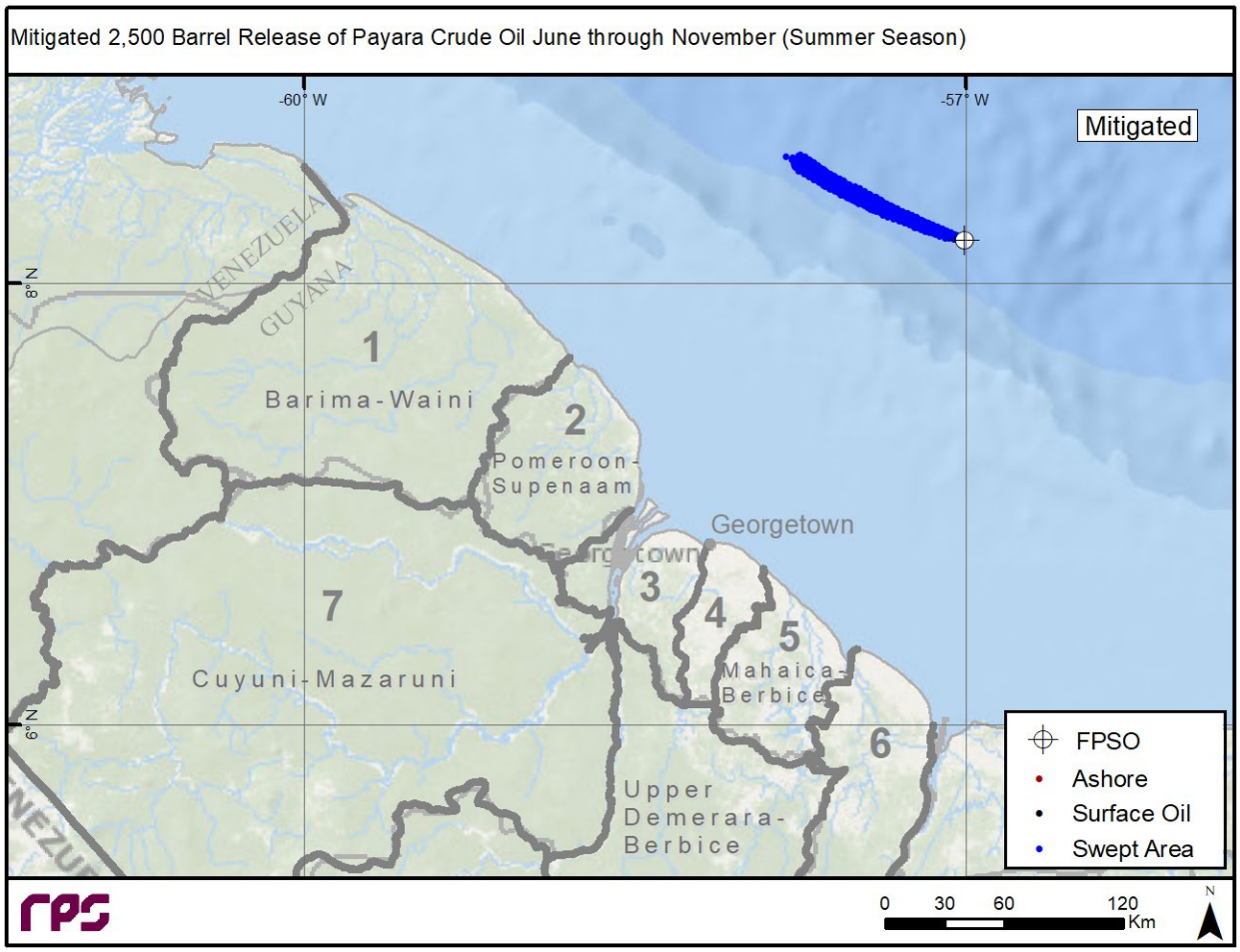


Figure 9.1-7b: (Zoomed In) Proxy Deterministic Map for Scenario 13—Predicted Transport after 10 Days from a Mitigated 2,500-Barrel (400 m^3) Surface Release of Crude Oil (Jun–Nov)

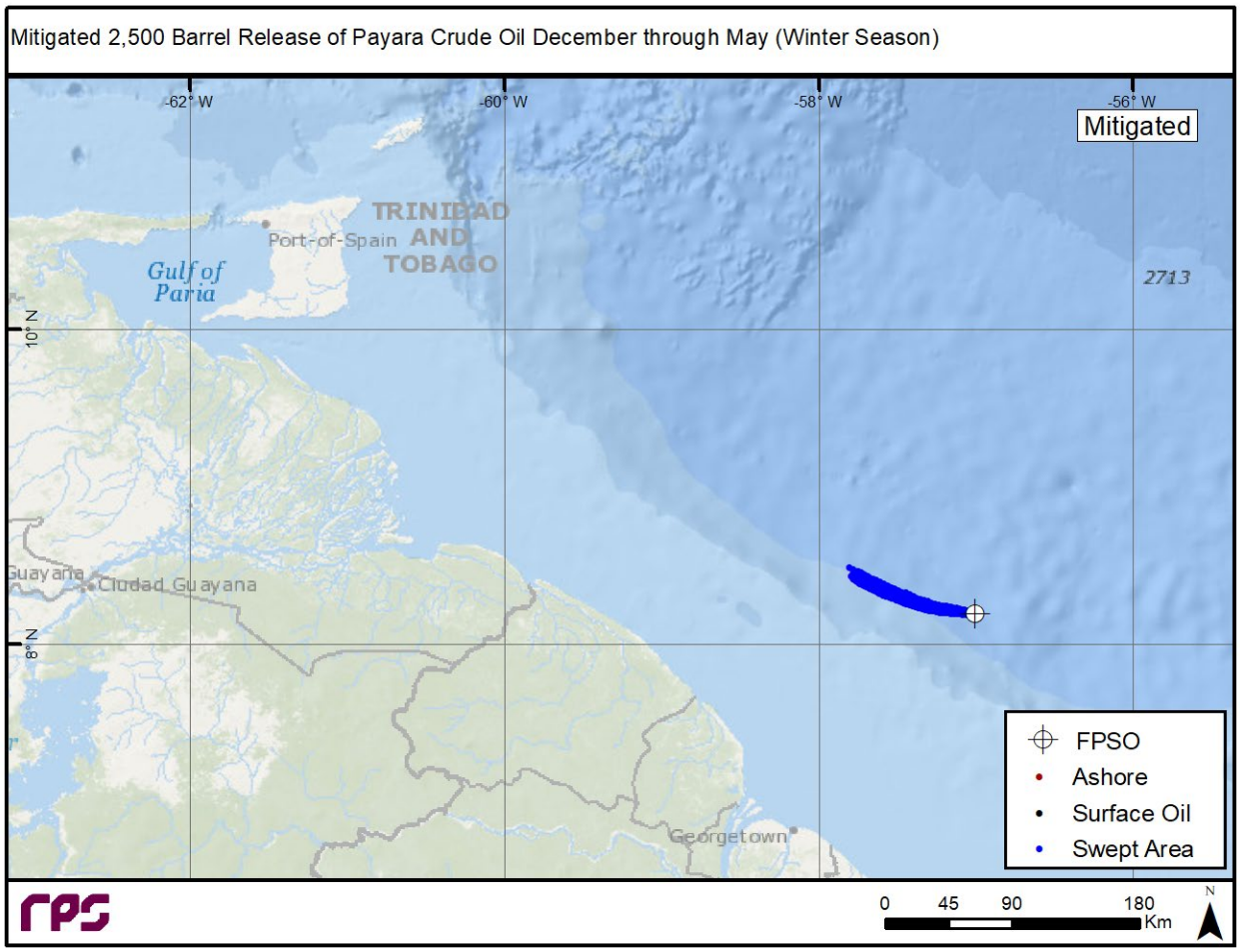


Figure 9.1-8a: Proxy Deterministic Map for Scenario 13—Predicted Transport after 10 Days from a Mitigated 2,500-Barrel (400 m^3) Surface Release of Crude Oil (Dec–May)

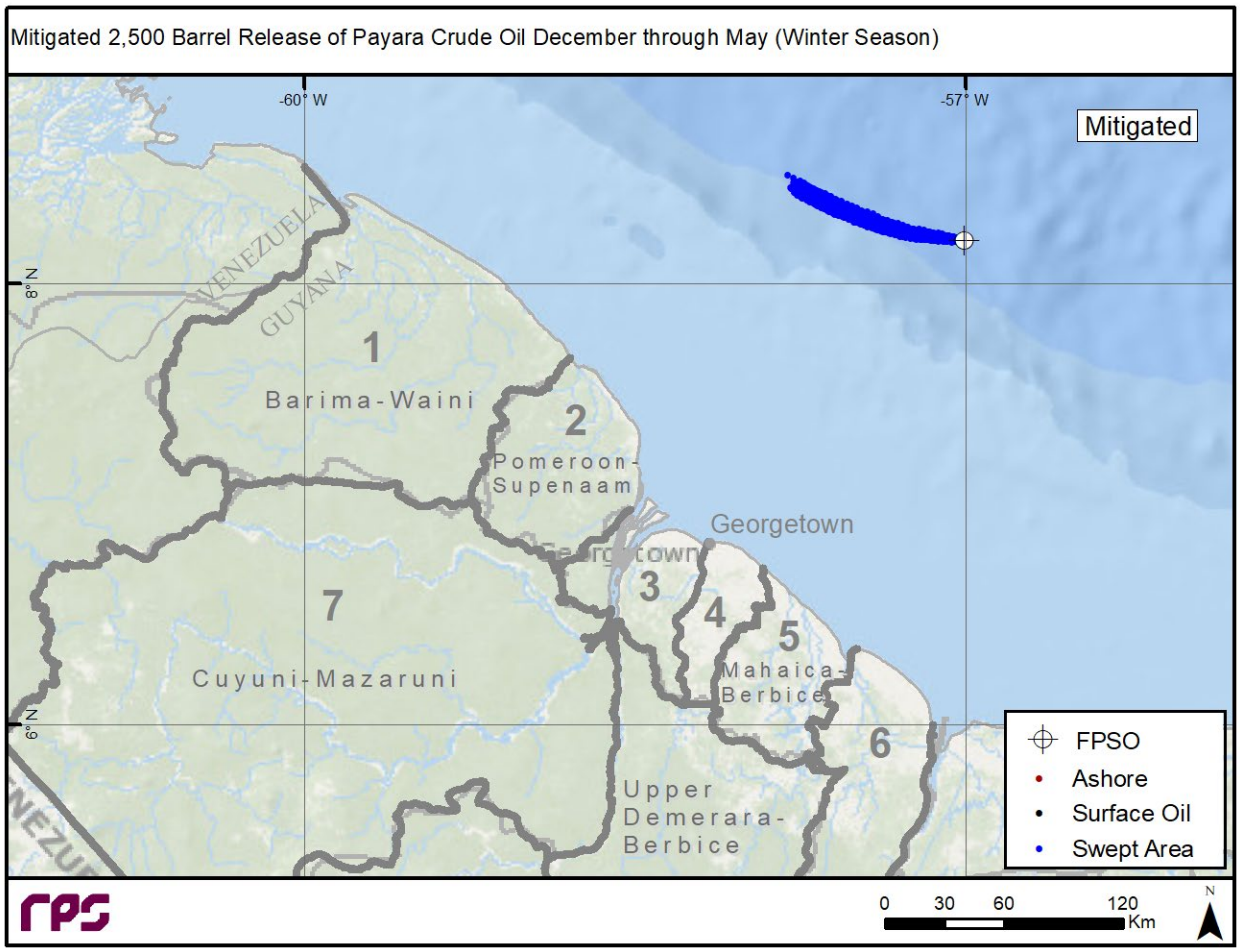


Figure 9.1-8b: (Zoomed In) Proxy Deterministic Map for Scenario 13—Predicted Transport after 10 Days from a Mitigated 2,500-Barrel (400 m^3) Surface Release of Crude Oil (Dec–May)

9.1.5.2. Scenario 14—Loss of Well Control Resulting in 30-Day Subsea Release of Crude Oil at 88,728 BPD (14,196 m^3; Most Credible WCD)

Figure 9.1-9a shows a stochastic map for sea surface oiling (without mitigation by response activities) resulting from Scenario 14 (a loss-of-well-control event that results in an 88,728 BPD (14,196 m^3) subsea release lasting for 30 days) in the Jun–Nov season. The top panel shows the probability of sea surface oiling above a minimum thickness of 1.0 g/m^2, and the bottom panel shows the minimum amount of time for sea surface oiling to achieve a minimum thickness of 1.0 g/m^2. Figure 9.1-9b shows the same stochastic map, zoomed in on the Guyanese coast.

Figures 9.1-10a and 9.1-10b show the stochastic maps for sea surface oiling (without mitigation by response activities) resulting from Scenario 14 in the Dec–May season.

Figure 9.1-11a shows a deterministic map (without mitigation by response activities) resulting from Scenario 14 in the Jun–Nov season. The dark blue area shows the "swept area," which is the aggregated area that the model predicts the unmitigated oil spill will have traveled across by the end of a 45-day modeling simulation. The black areas show the oil predicted to be remaining on the surface at the end of the 45-day modeling simulation. The red areas indicate where the oil is predicted to have made shoreline contact at the end of the 45-day modeling simulation, all based on the minimum thickness threshold. Figure 9.1-11b shows the same deterministic map zoomed in on the Guyanese coast.

Figures 9.1-12a and 9.1-12b show the deterministic maps (without mitigation by response activities) resulting from Scenario 14 in the Dec–May season.

Figures 9.1-13a and 9.1-13b show the deterministic maps (with mitigation by response activities) resulting from Scenario 14 in the Jun–Nov season. Figures 9.1-14a and 9.1-14b show the deterministic maps (with mitigation by response activities) resulting from Scenario 14 in the Dec–May season. The events with mitigation measures applied were simulated assuming a capping stack stops the flow of oil and gas at the end of day 5.5, assuming no debris removal, and using dispersant application from aircrafts and vessels, mechanical recovery, and *in-situ* burning of surface oil. The model was run for an additional 40 days after installation of the capping stack, for a total length of simulation of 45.5 days. If the release is stopped within 5.5 days and spill response measures are applied, the modeling predicts a significantly reduced extent of surface movement of the spill and no impacts on the Guyana coastline. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

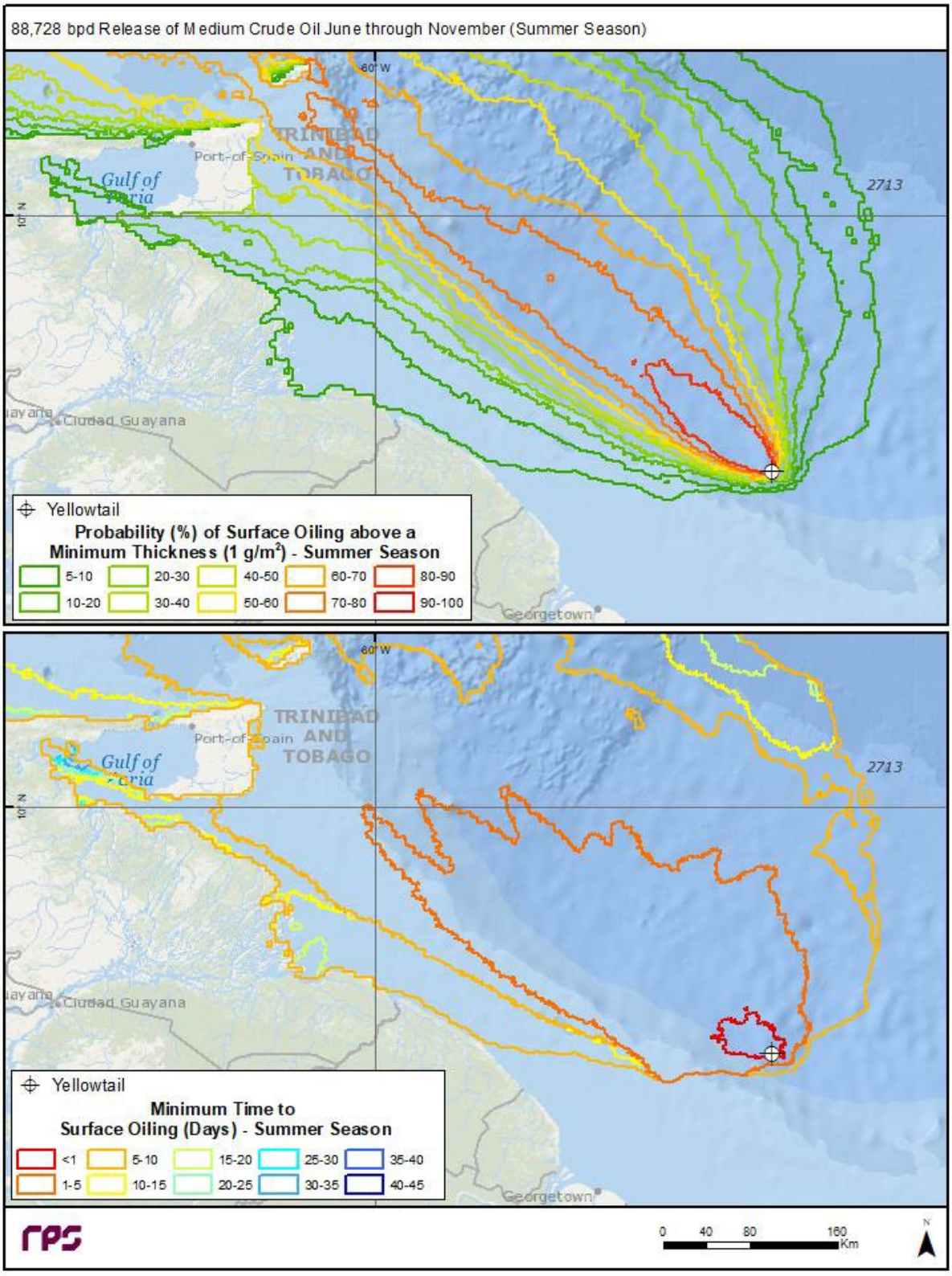


Figure 9.1-9a: Stochastic Map for Scenario 14—Predicted Surface Oiling and Timing from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days (Jun–Nov)

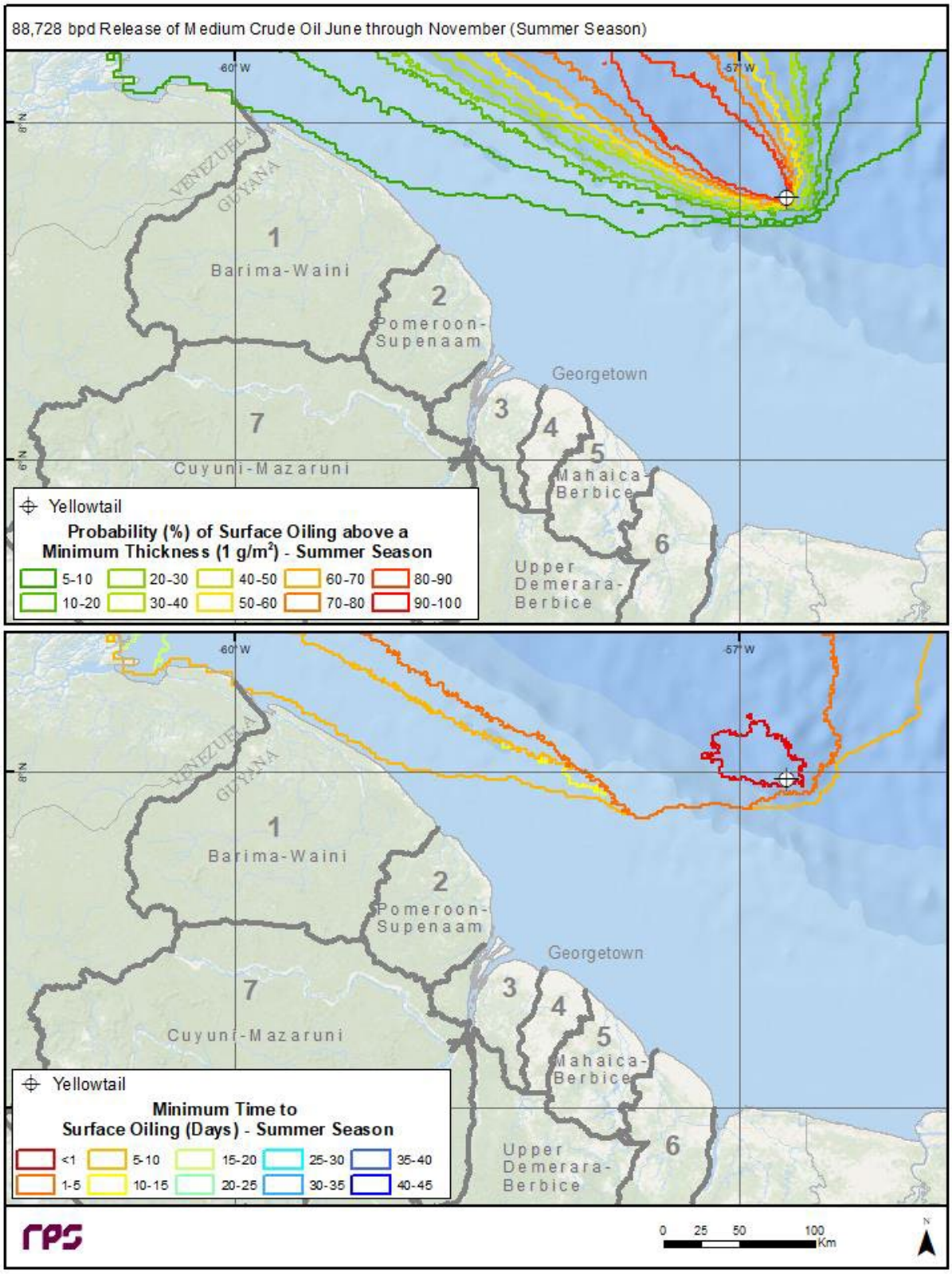


Figure 9.1-9b: (Zoomed In) Stochastic Map for Scenario 14—Predicted Surface Oiling and Timing from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days (Jun–Nov)

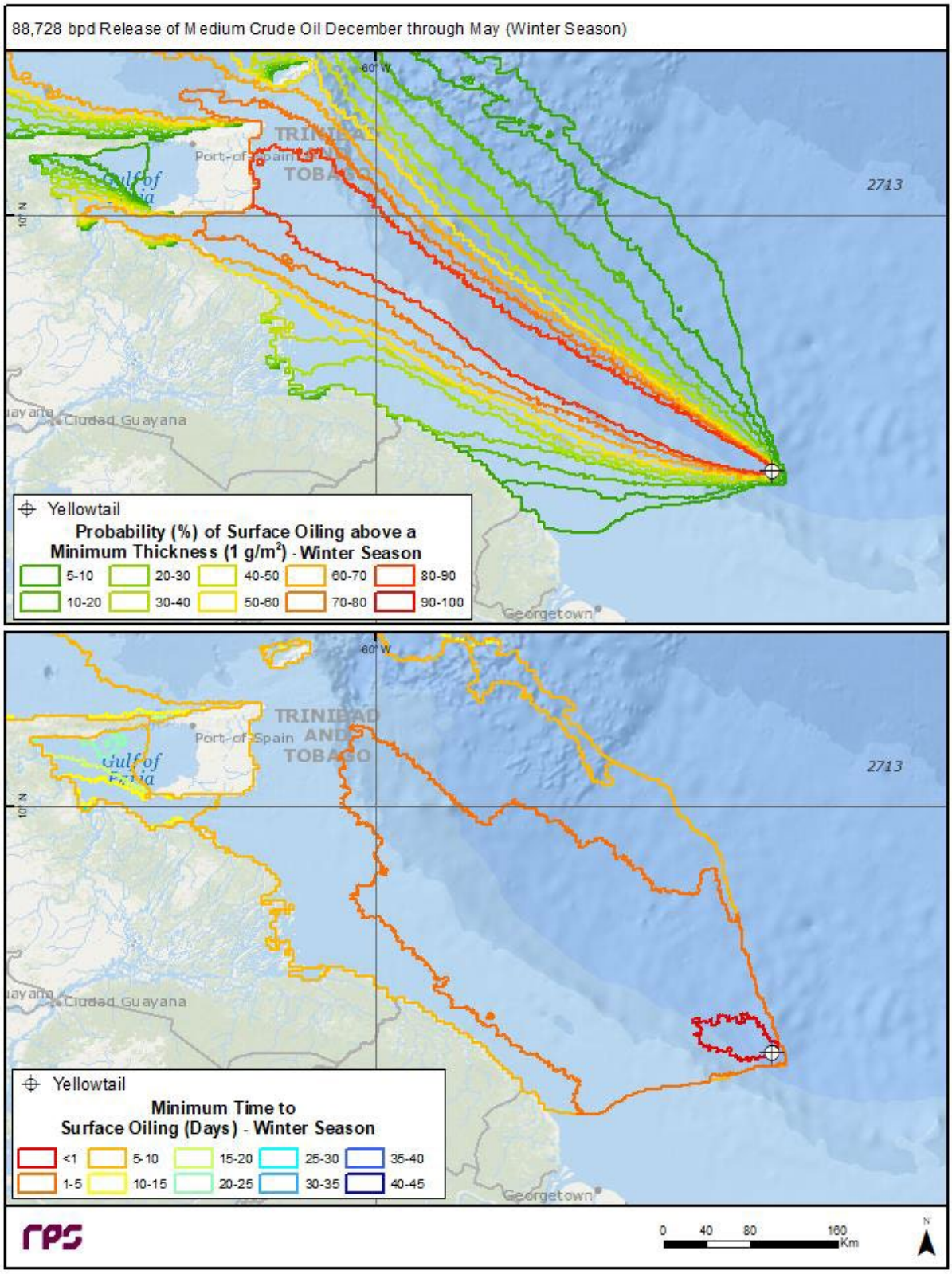


Figure 9.1-10a: Stochastic Map for Scenario 14—Predicted Surface Oiling and Timing from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days (Dec–May)

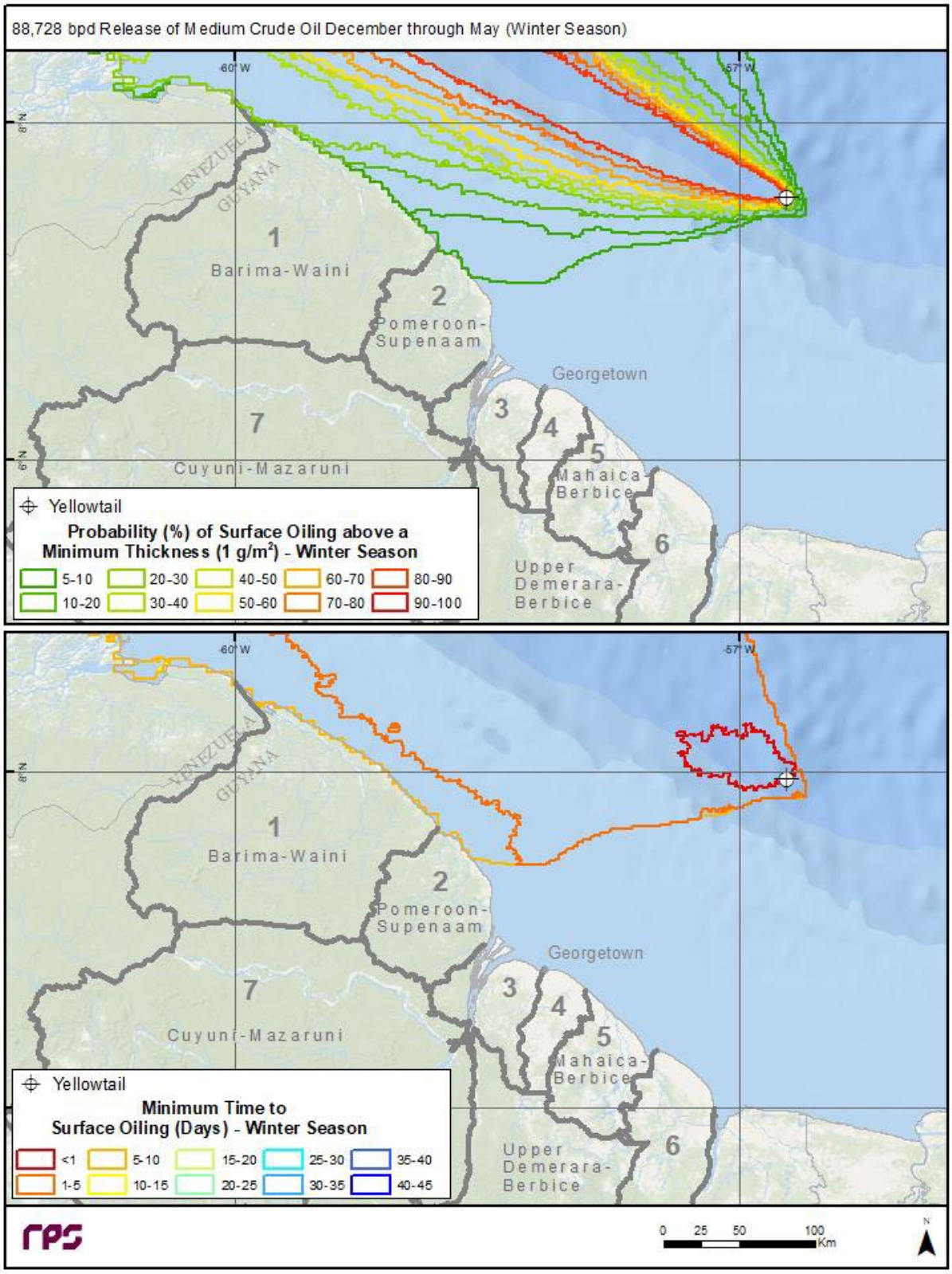


Figure 9.1-10b: (Zoomed In) Stochastic Map for Scenario 14—Predicted Surface Oiling and Timing from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days (Dec–May)

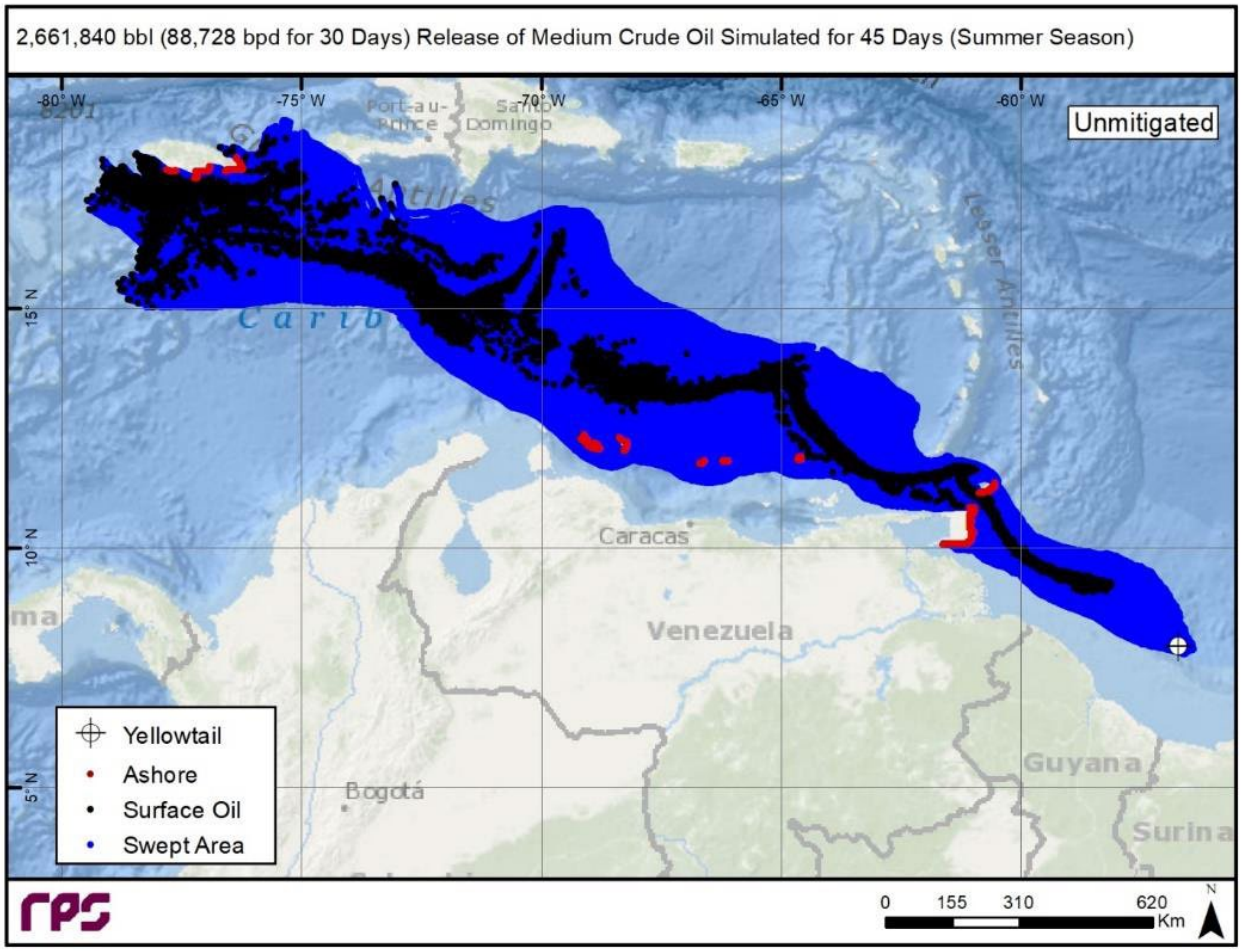


Figure 9.1-11a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days (Jun–Nov)

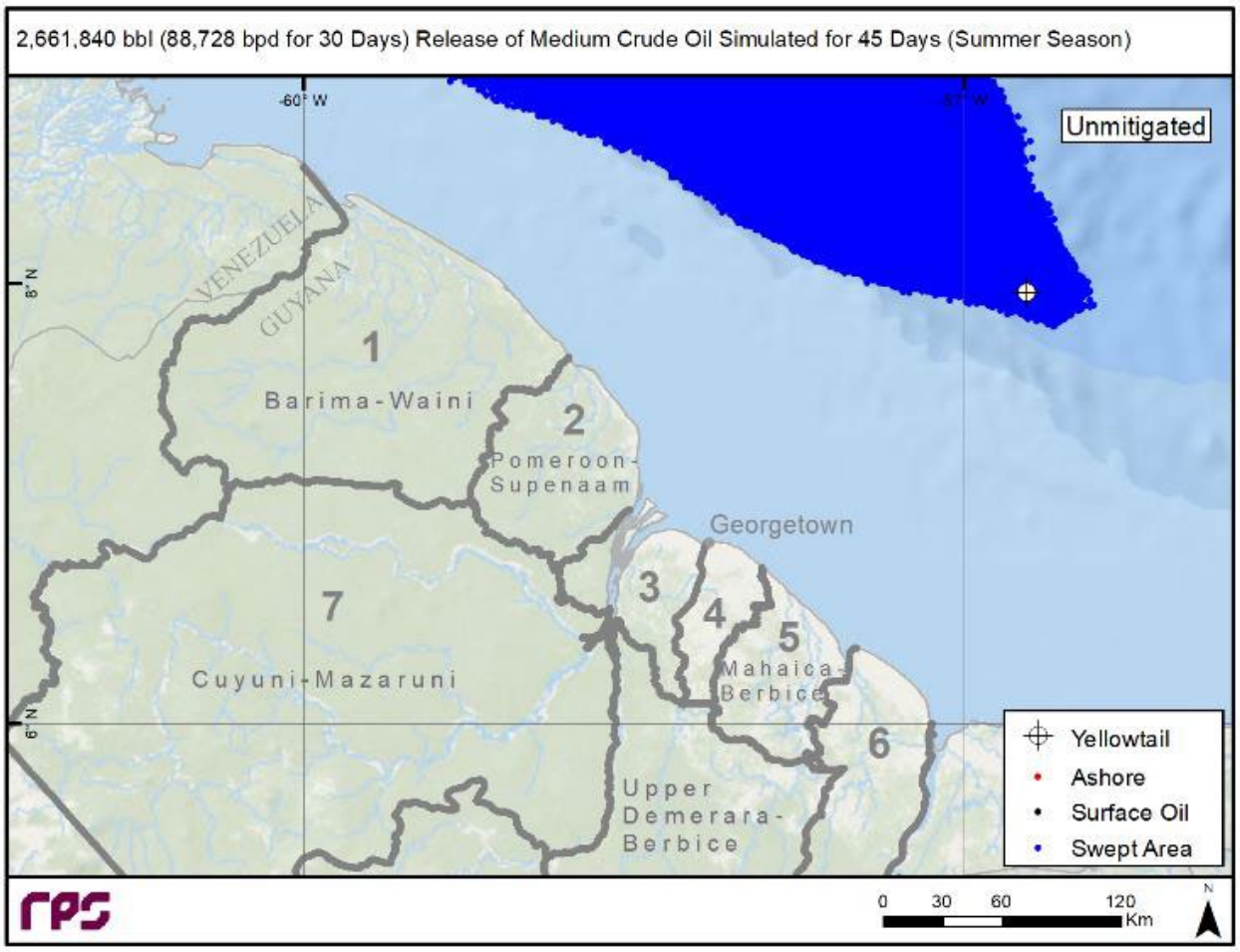


Figure 9.1-11b: (Zoomed In) Deterministic Map for Scenario 14—Predicted Transport after 45 days from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days (Jun–Nov)

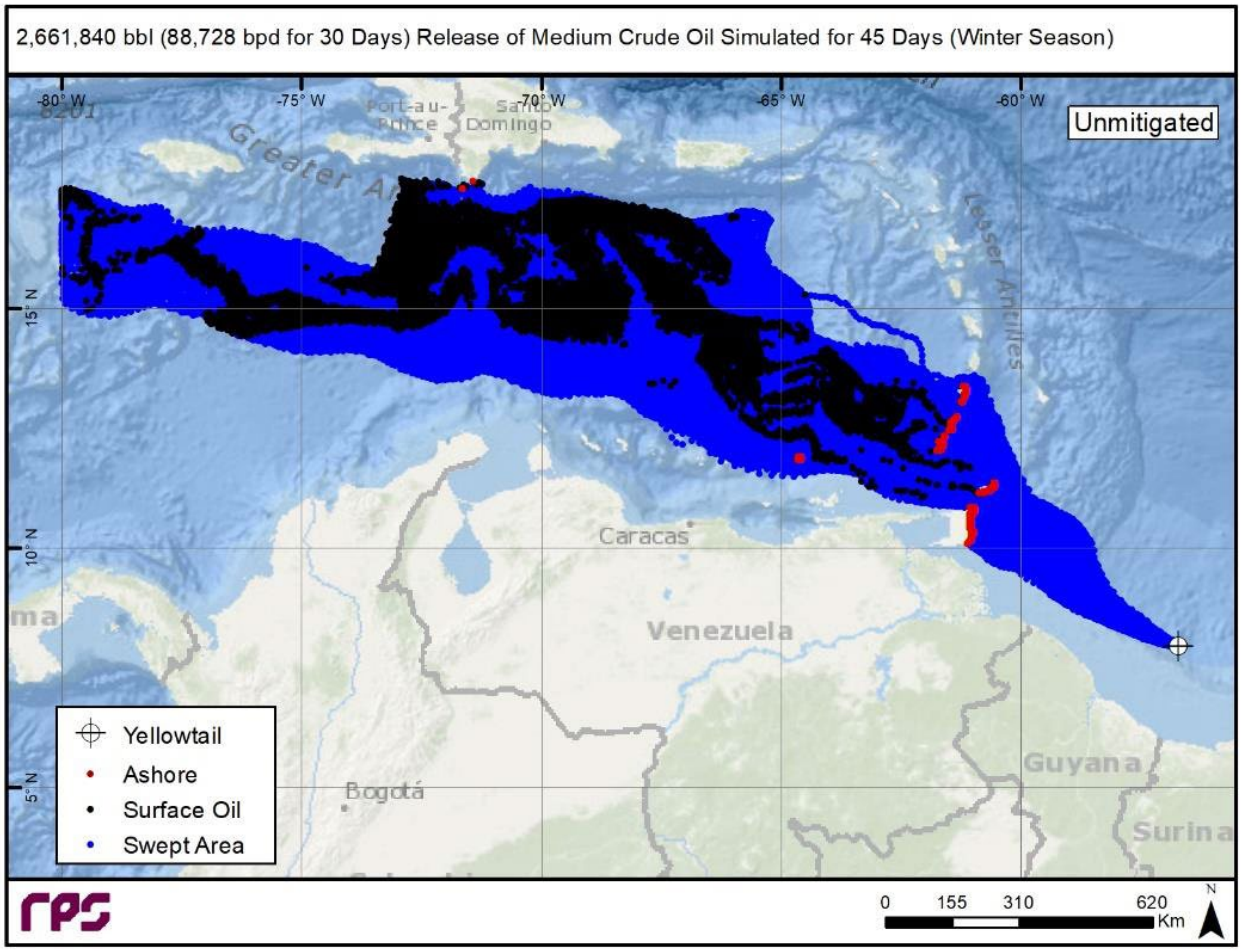


Figure 9.1-12a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days (Dec–May)

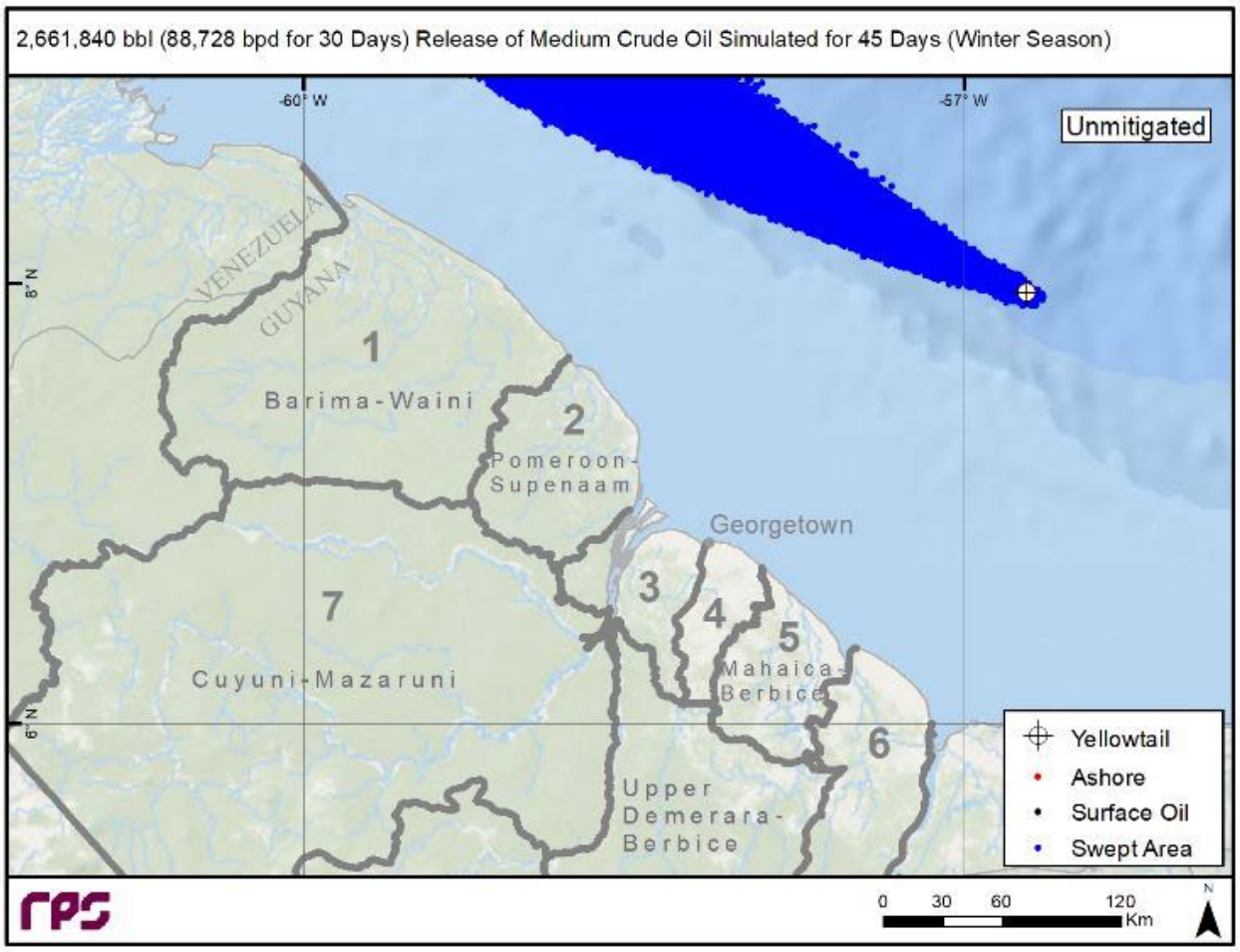


Figure 9.1-12b: (Zoomed In) Deterministic Map for Scenario 14—Predicted Transport after 45 Days from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days (Dec–May)

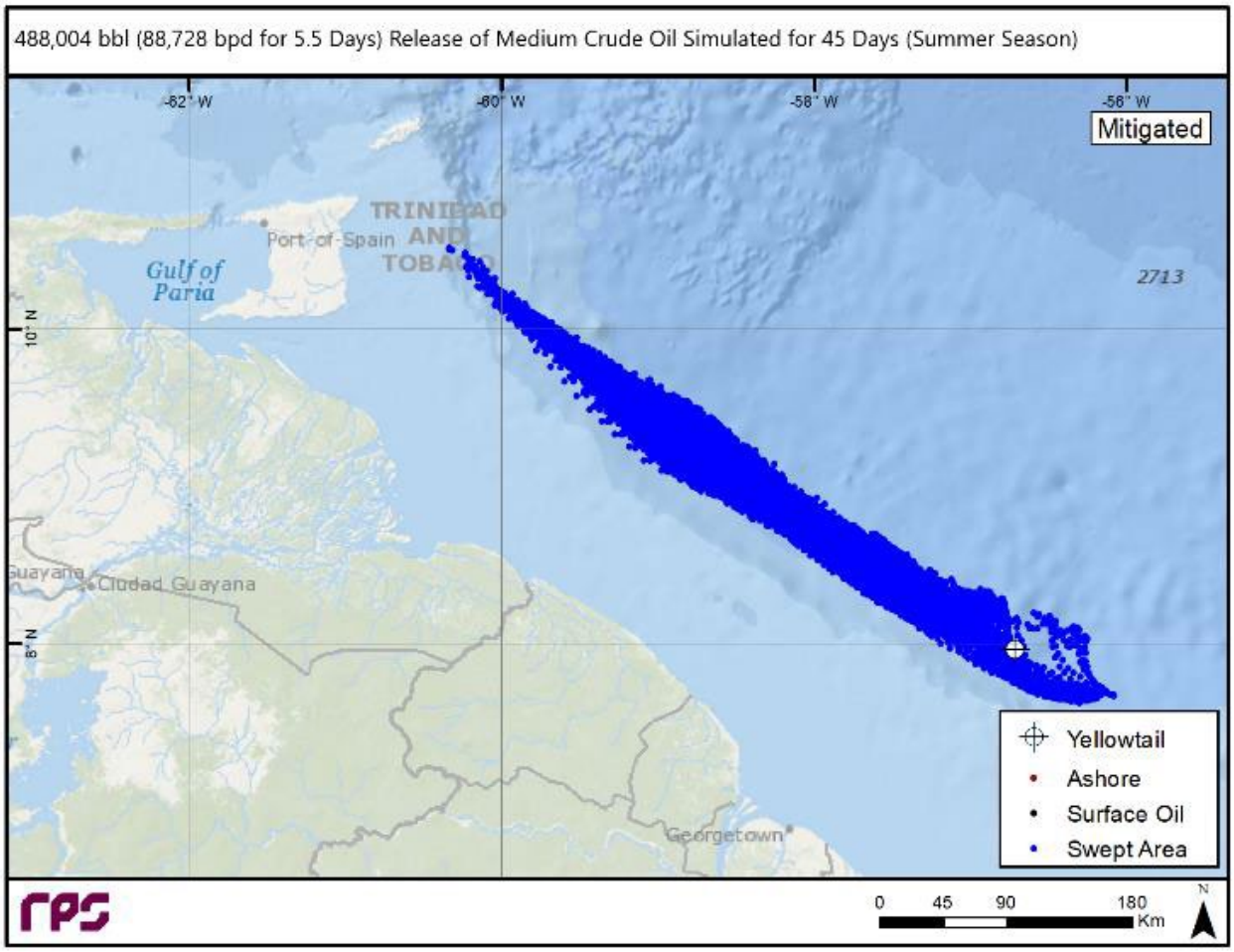


Figure 9.1-13a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from a Mitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil—Capped After 5.5 Days (Jun–Nov)

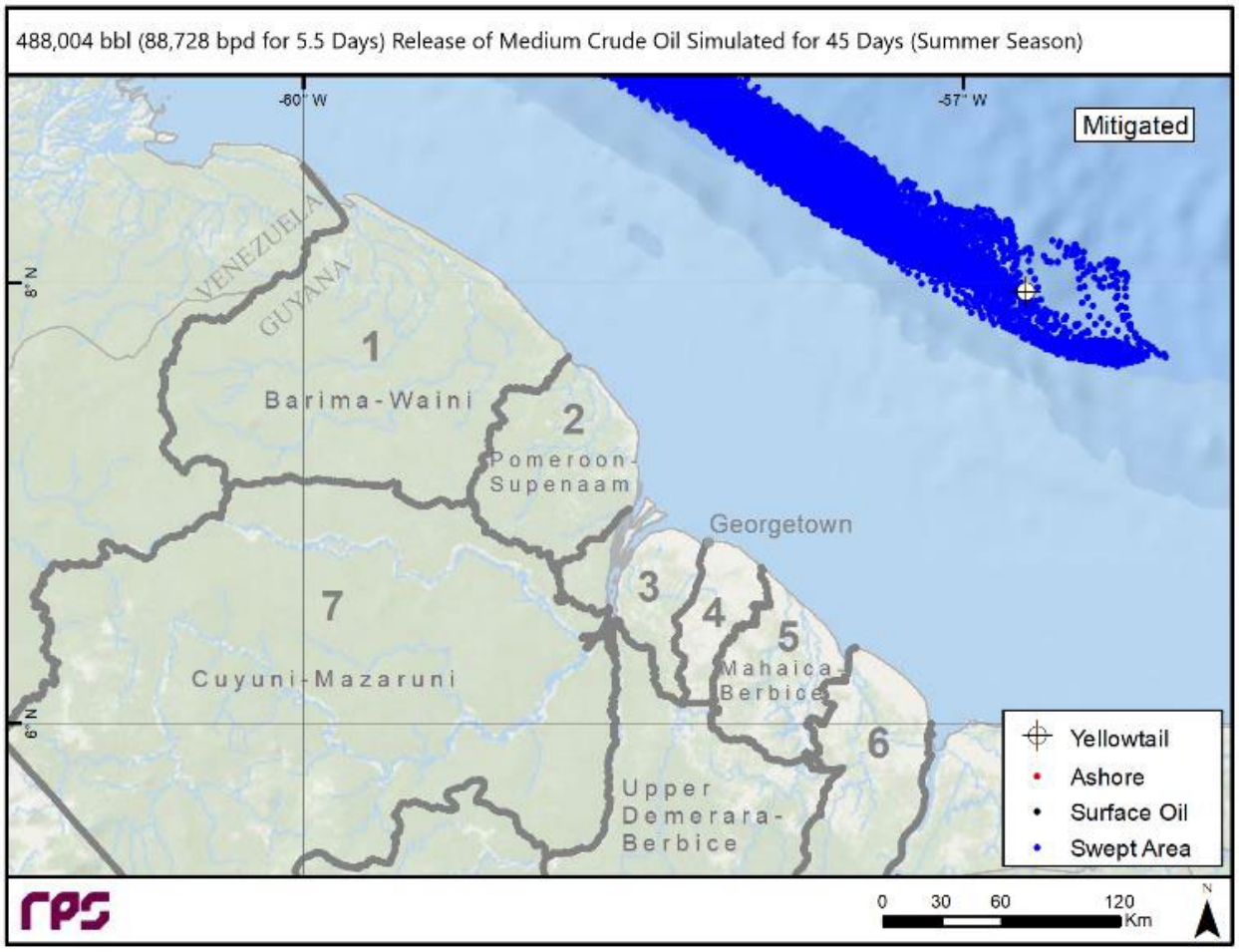


Figure 9.1-13b: (Zoomed In) Deterministic Map for Scenario 14—Predicted Transport after 45 Days from a Mitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil—Capped After 5.5 Days (Jun–Nov)

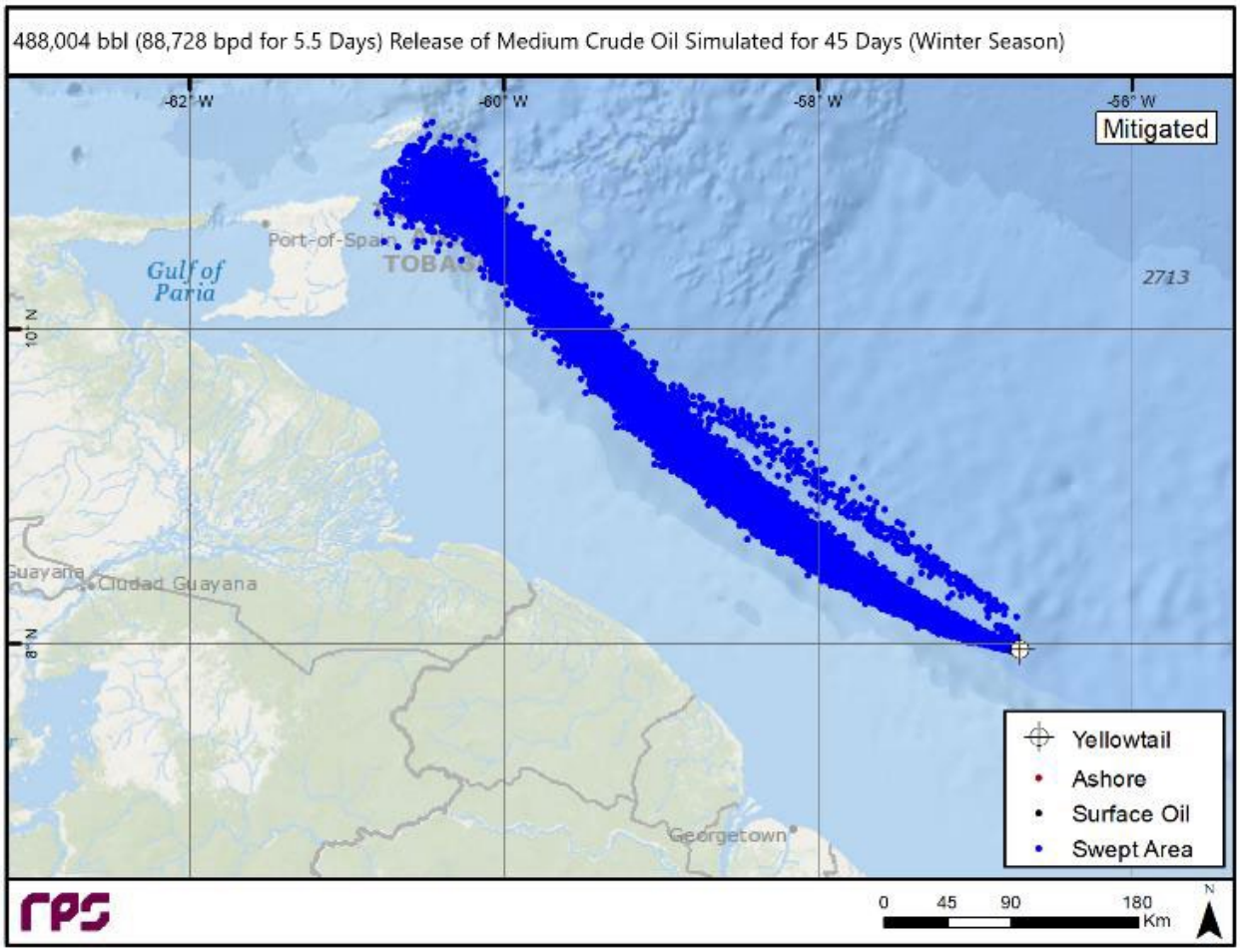


Figure 9.1-14a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from a Mitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil—Capped After 5.5 Days (Dec–May)

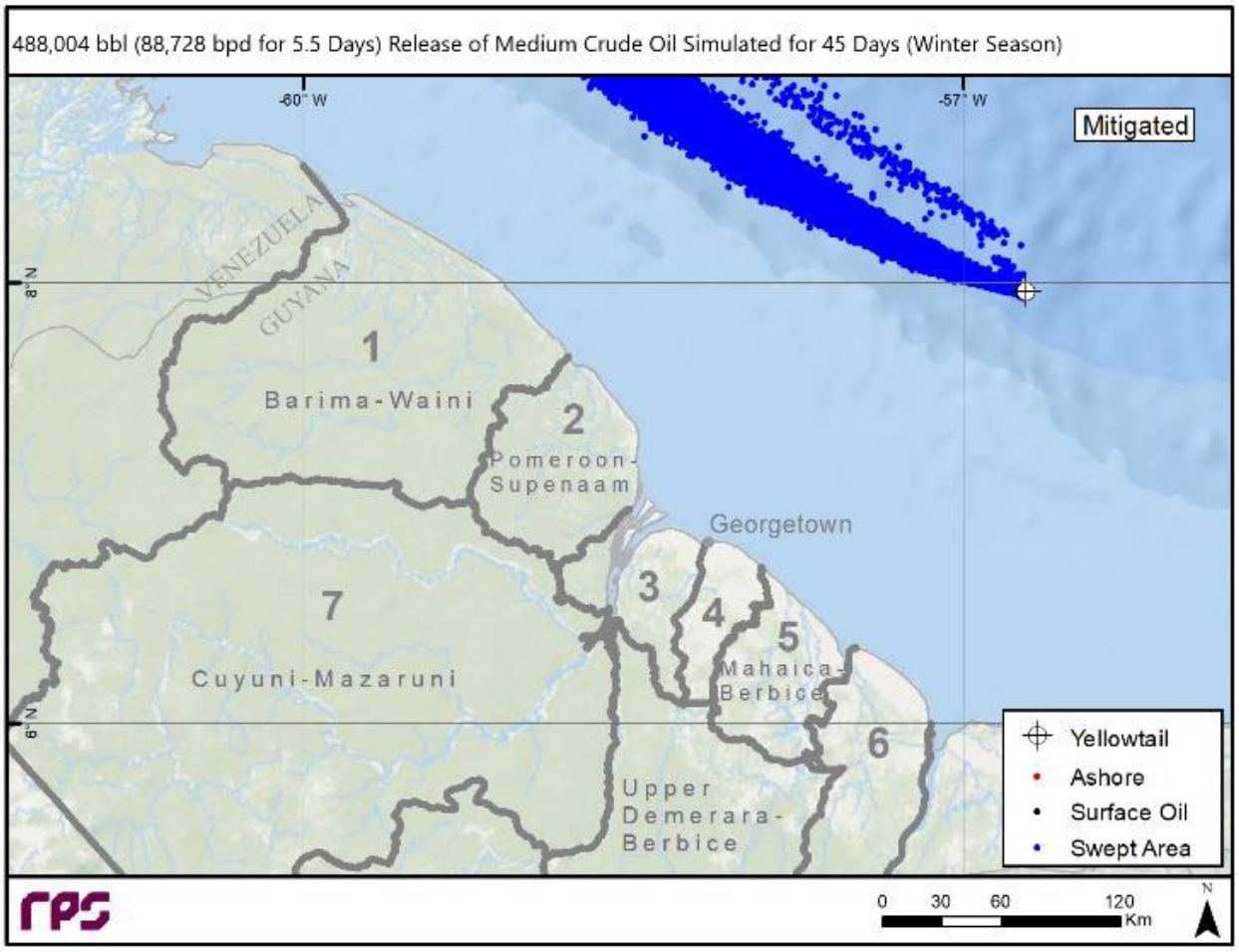


Figure 9.1-14b: (Zoomed In) Deterministic Map for Scenario 14—Predicted Transport after 45 Days from a Mitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil—Capped After 5.5 Days (Dec–May)

9.1.5.3. Scenario 15—Loss-of-Well-Control Resulting in 30-Day Subsea Release of Crude Oil at 177,157 BPD (28,345 m^3; Maximum WCD)

Figure 9.1-15a shows a stochastic map for sea surface oiling (without mitigation by response activities) resulting from Scenario 15 (a loss-of-well-control event that results in a 177,157 BPD (28,345 m^3) subsea release lasting for 30 days) in the Jun–Nov season. The top panel shows the probability of sea surface oiling above a minimum thickness of 1.0 g/m^2 and the bottom panel shows the minimum amount of time for sea surface oiling above a minimum thickness of 1.0 g/m^2. Figure 9.1-15b shows the same stochastic map, zoomed in on the Guyanese coast.

Figures 9.1-16a and 9.1-16b show the stochastic maps for sea surface oiling (without mitigation by response activities) resulting from Scenario 15 in the Dec–May season.

Figure 9.1-17a shows a deterministic map (without mitigation by response activities) resulting from Scenario 15 in the Jun–Nov season. The dark blue area shows the "swept area," which is the aggregated area that the model predicts the oil spill will have traveled across by the end of a 45-day modeling simulation. The black areas show the oil predicted to be remaining on the surface at the end of the 45-day modeling simulation. The red areas indicate where the oil is predicted to have made shoreline contact at the end of the 45-day modeling simulation, all based on the minimum thickness threshold. Figure 9.1-17b shows the same deterministic map zoomed in on the Guyanese coast.

Figures 9.1-18a and 9.1-18b show the deterministic maps (without mitigation by response activities) resulting from Scenario 15 in the Dec–May season.

Figures 9.1-19a and 9.1-19b show the deterministic maps (with mitigation by response activities) resulting from Scenario 15 in the Jun–Nov season. Figures 9.1-20a and 9.1-20b show the deterministic maps (with mitigation by response activities) resulting from Scenario 15 in the Dec–May season. The events with mitigation measures applied were simulated assuming a capping stack stops the flow of oil and gas at the end of day 5.5, assuming no debris removal, and using water surface dispersant application from aircrafts and vessels, mechanical recovery and *in-situ* burning of surface oil. The model was run for an additional 40 days after installation of the capping stack, for a total length of simulation of 45.5 days. No shoreline impacts are expected in Guyana for a Maximum WCD event in summer regardless if mitigation measures are applied. Shoreline impacts would be expected in Region 1 during winter, even with the successful application of mitigation measures. If a release is stopped within 5.5 days and spill response measures are applied, the modeling predicts a significantly reduced extent of surface movement of a spill during both seasons. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

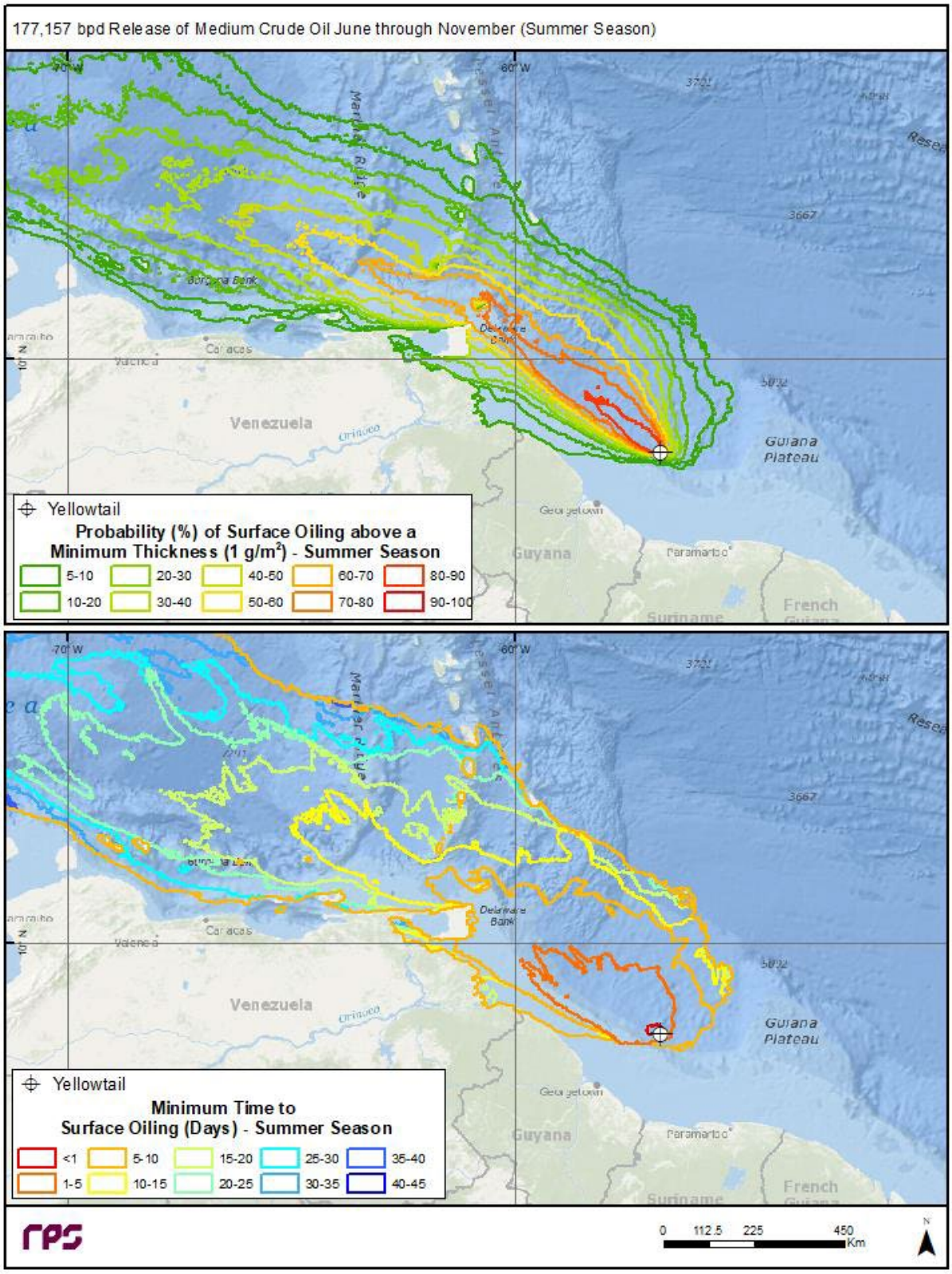


Figure 9.1-15a: Stochastic Map for Scenario 15—Predicted Surface Oiling and Timing from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days (Jun–Nov)

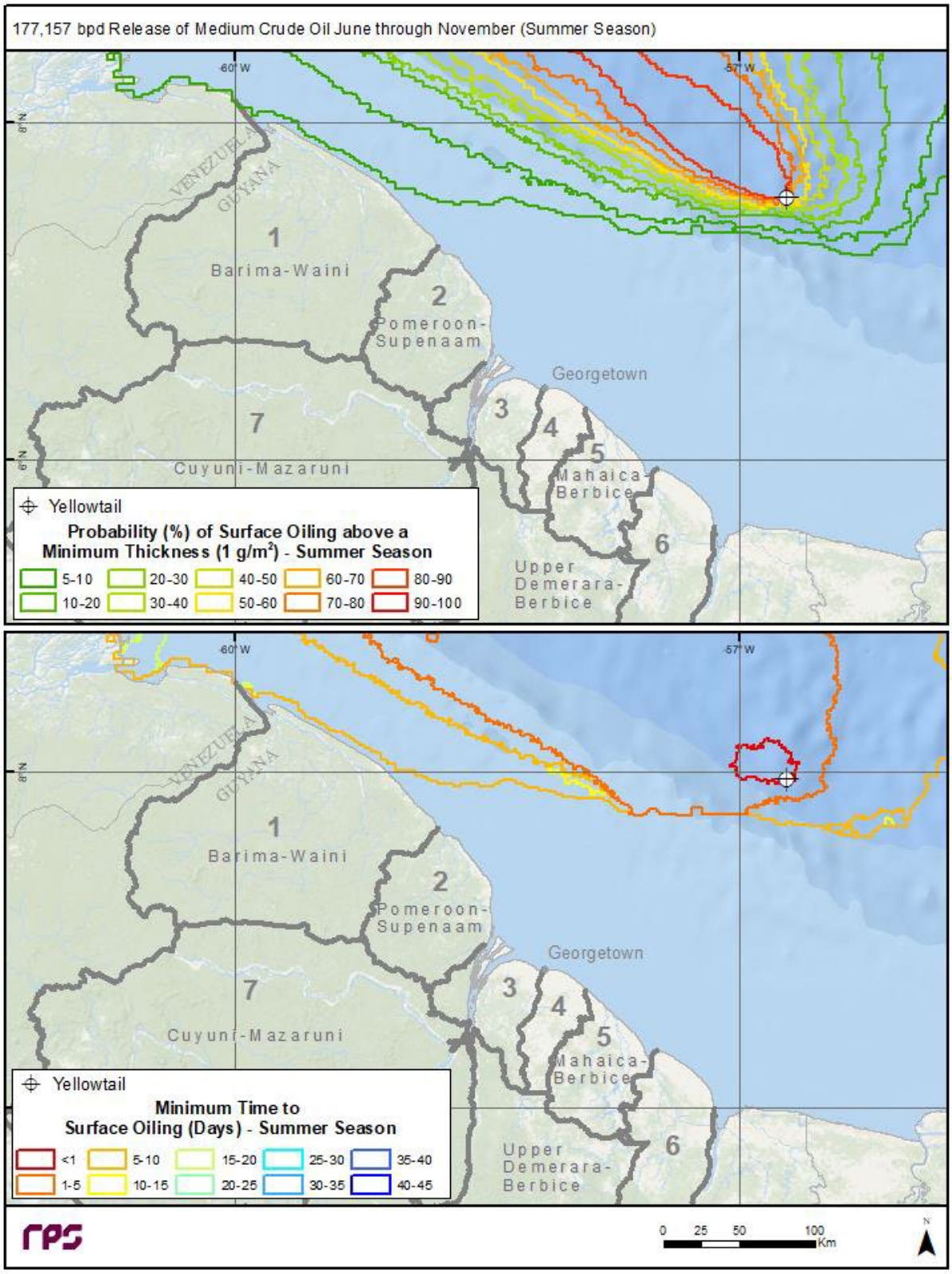


Figure 9.1-15b: (Zoomed In) Stochastic Map for Scenario 15—Predicted Surface Oiling and Timing from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days (Jun–Nov)

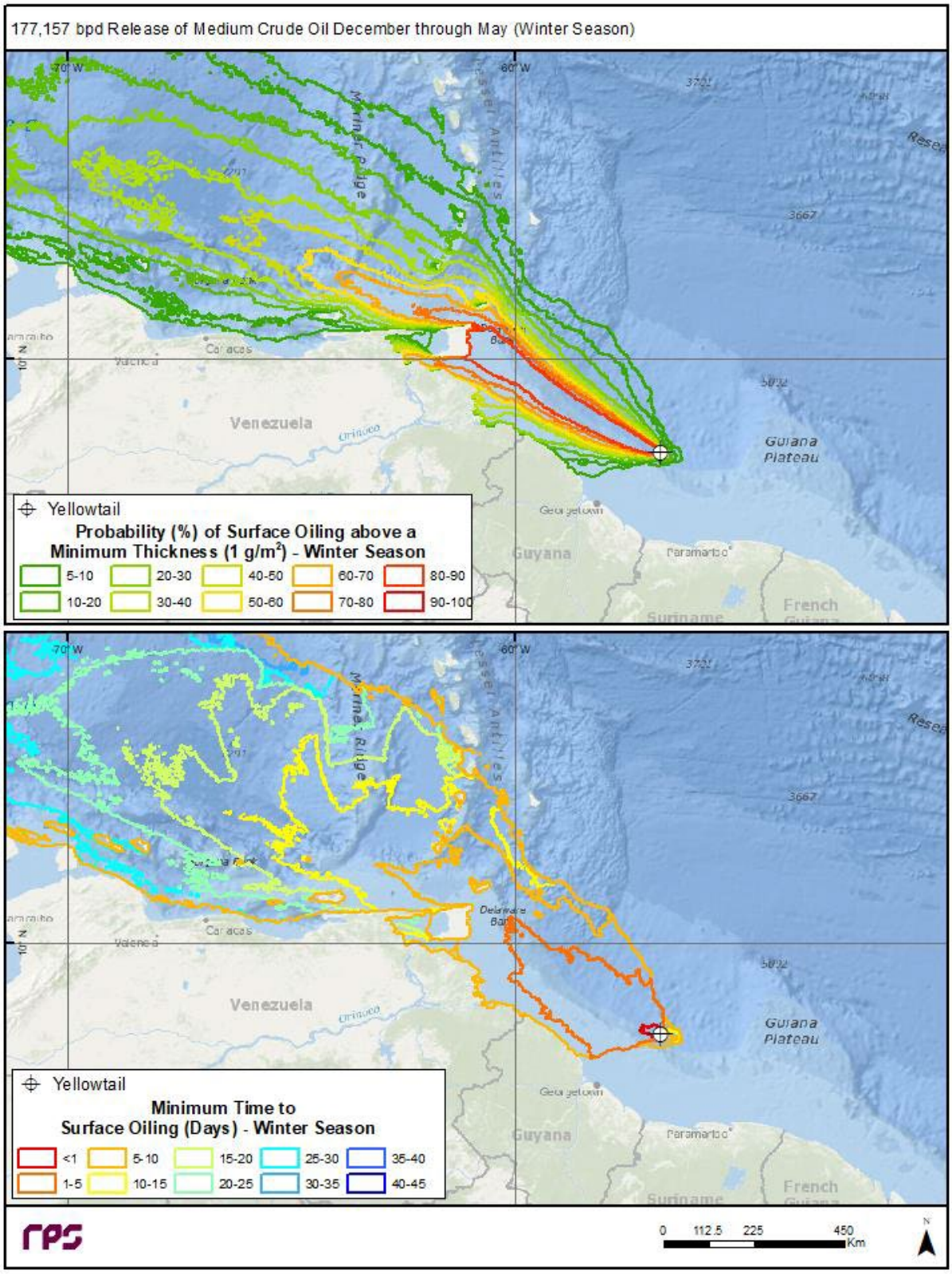


Figure 9.1-16a: Stochastic Map for Scenario 15—Predicted Surface Oiling and Timing from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days (Dec–May)

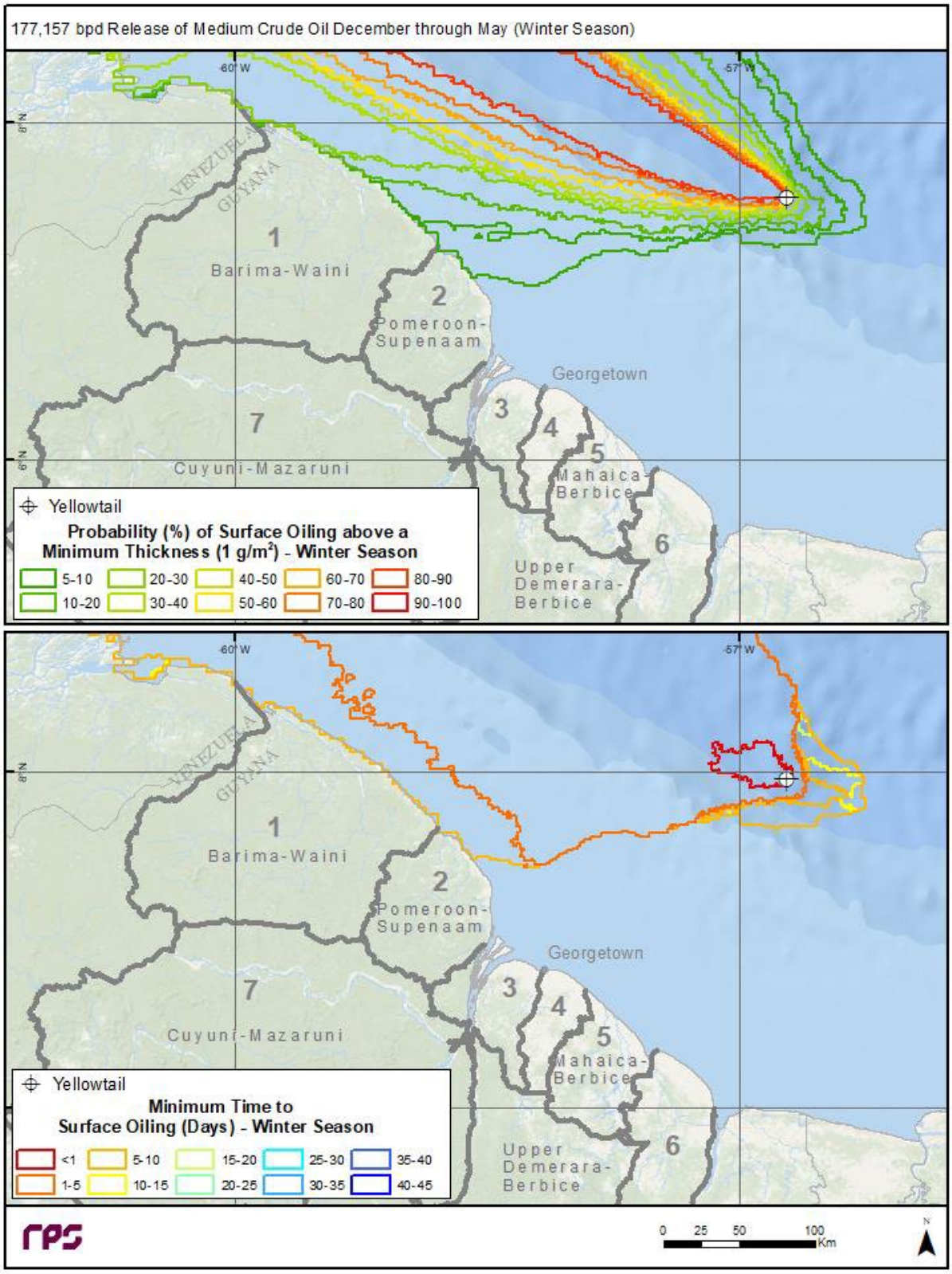


Figure 9.1-16b: (Zoomed In) Stochastic Map for Scenario 15—Predicted Surface Oiling and Timing from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days (Dec–May)

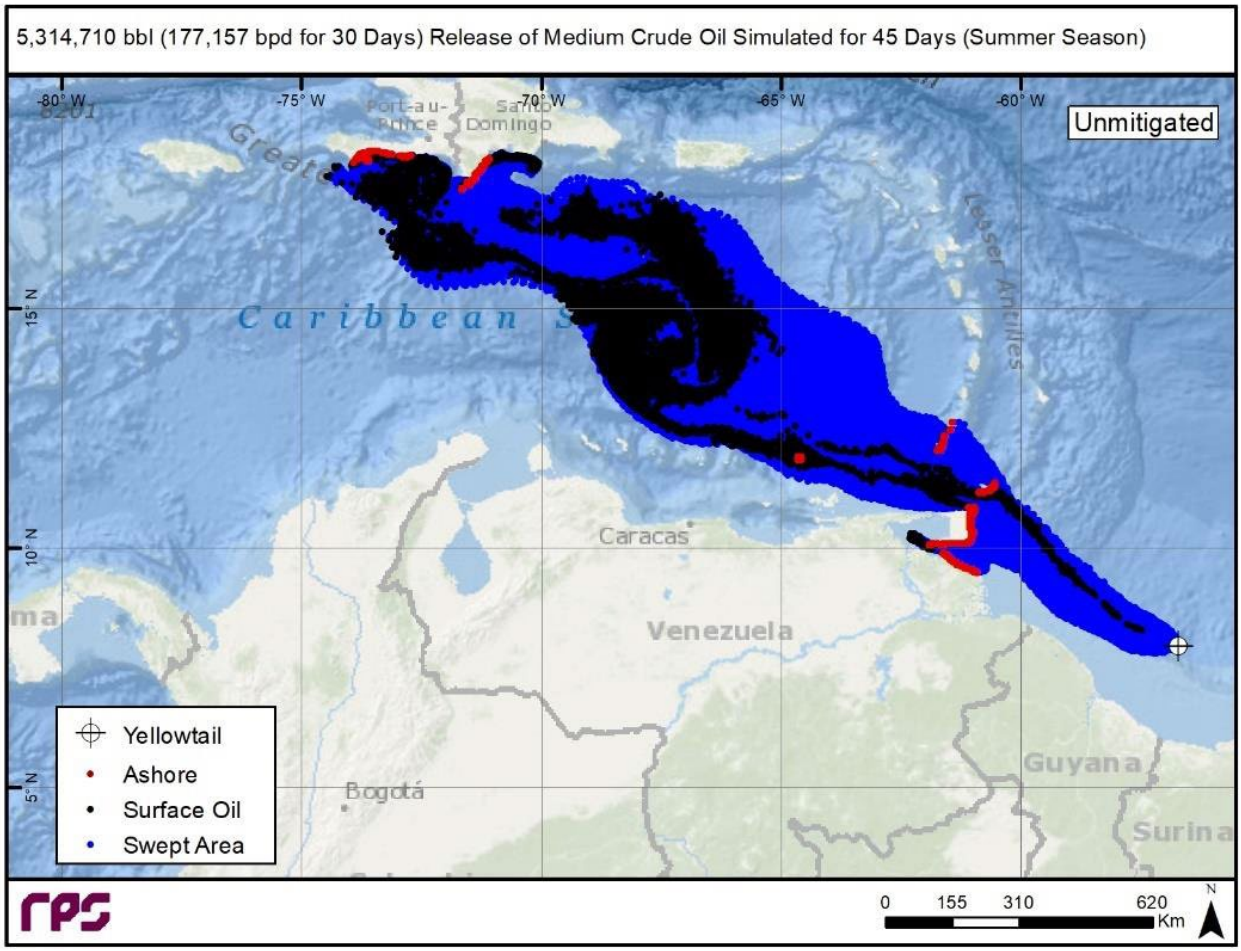


Figure 9.1-17a: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days (Jun–Nov)

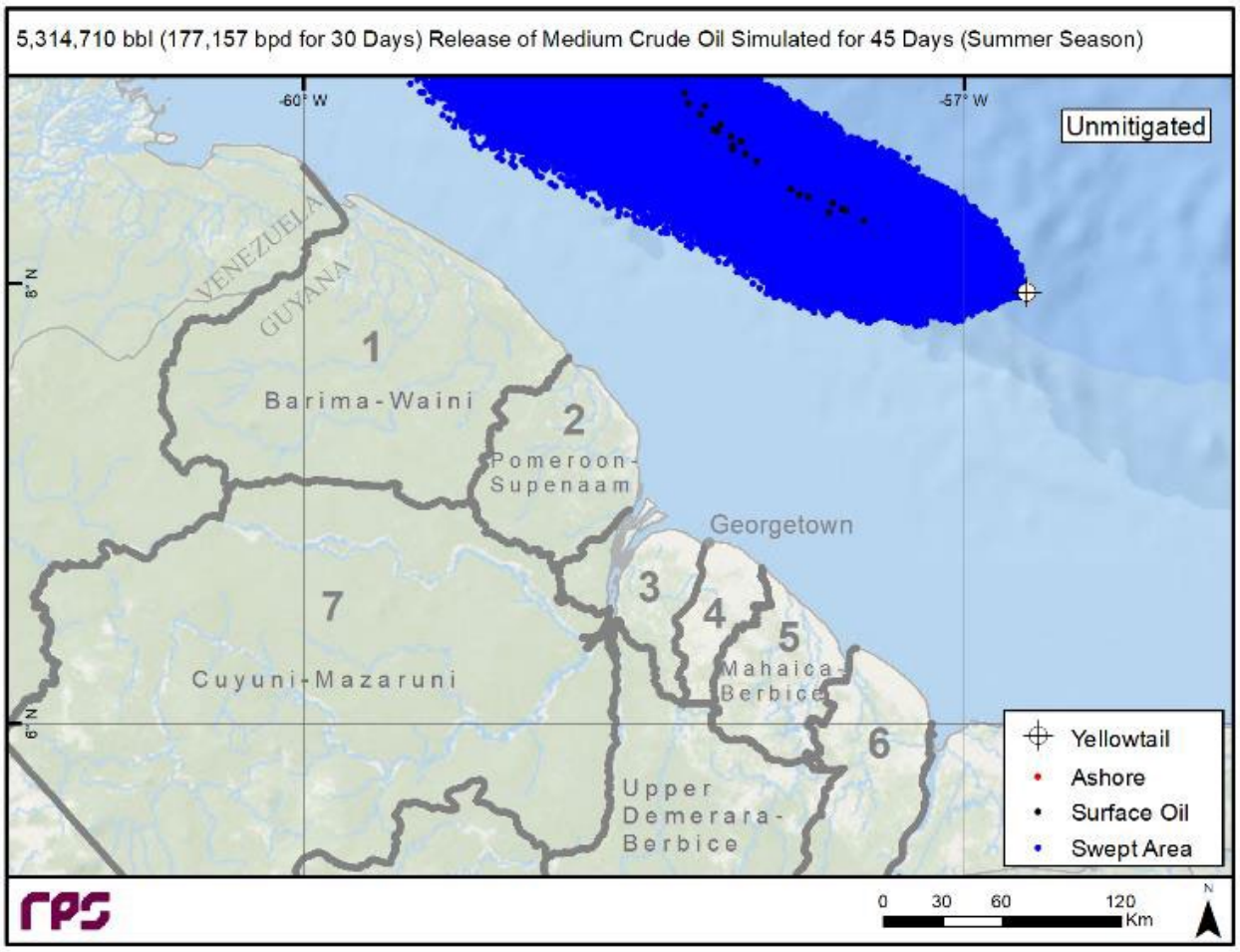


Figure 9.1-17b: (Zoomed In) Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days (Jun–Nov)

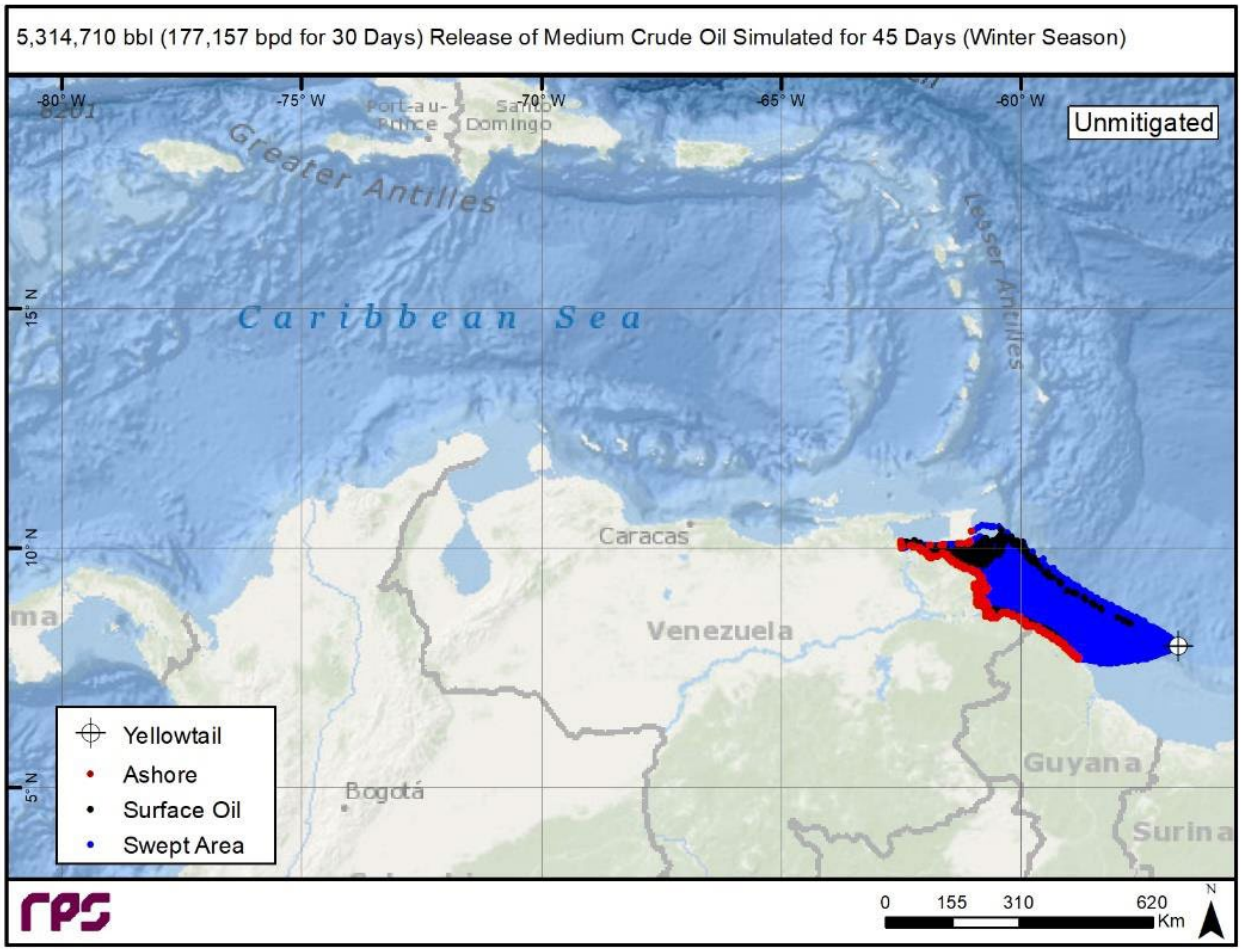


Figure 9.1-18a: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days (Dec–May)

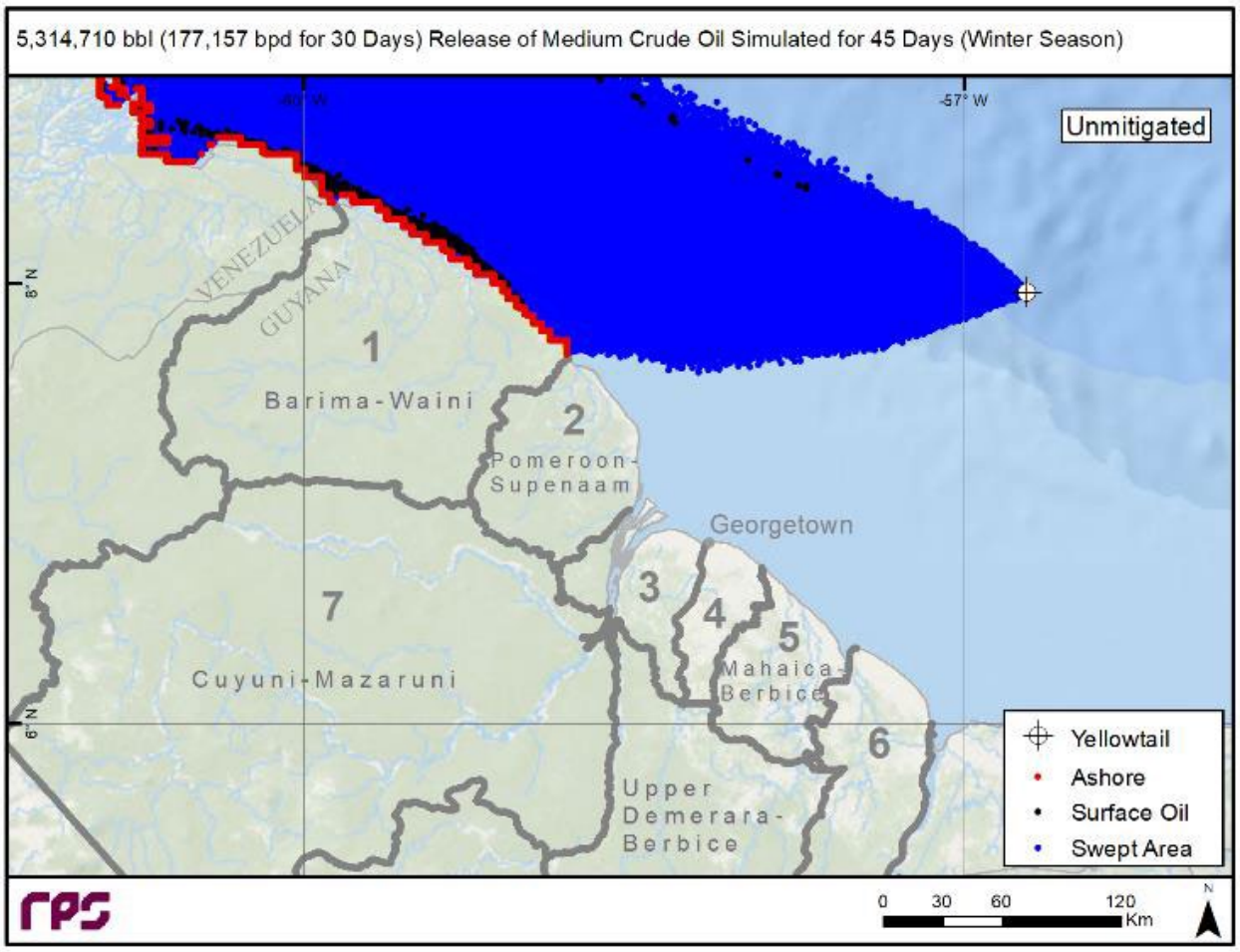


Figure 9.1-18b: (Zoomed In) Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days (Dec–May)

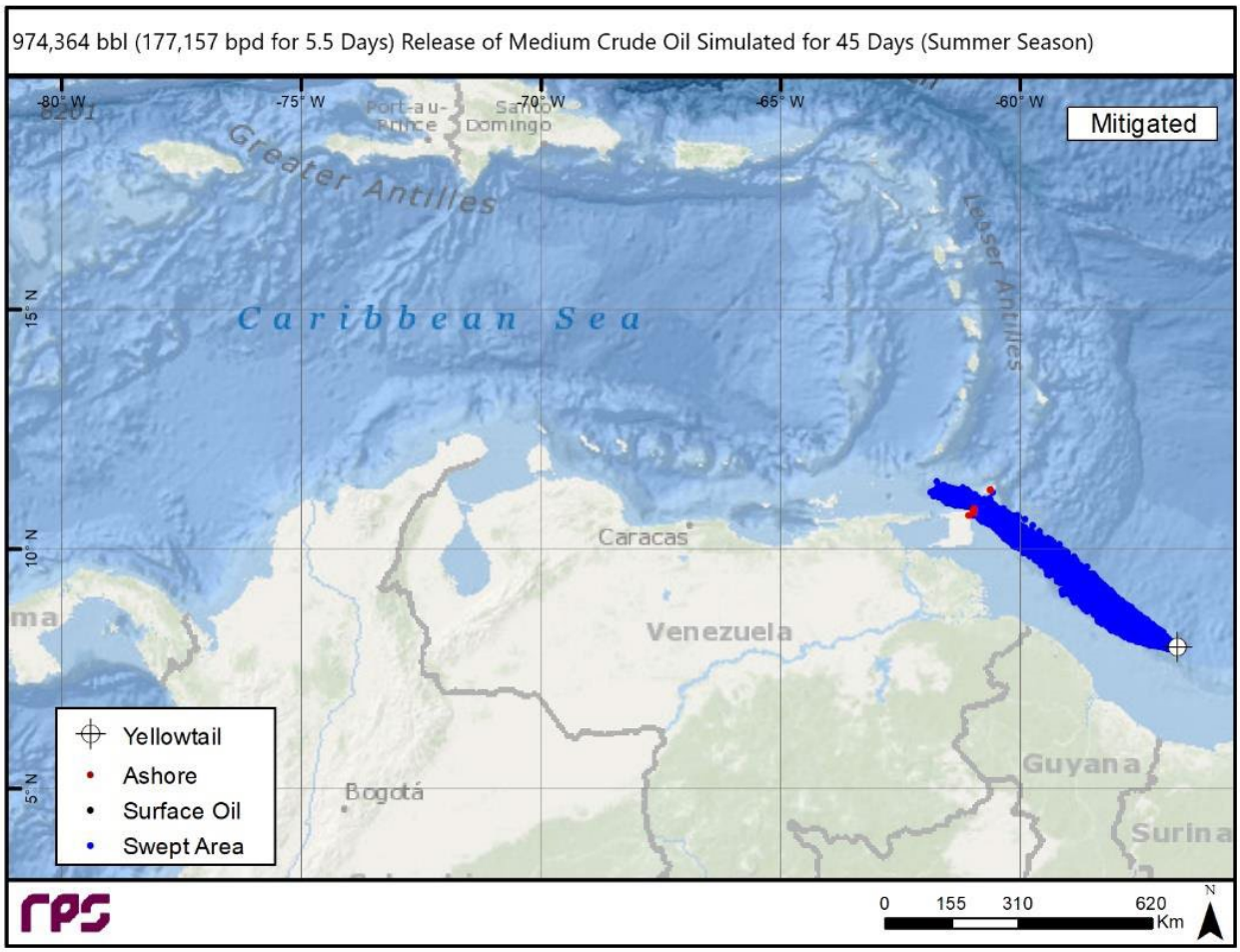


Figure 9.1-19a: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from a Mitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil—Capped After 5.5 Days (Jun–Nov)

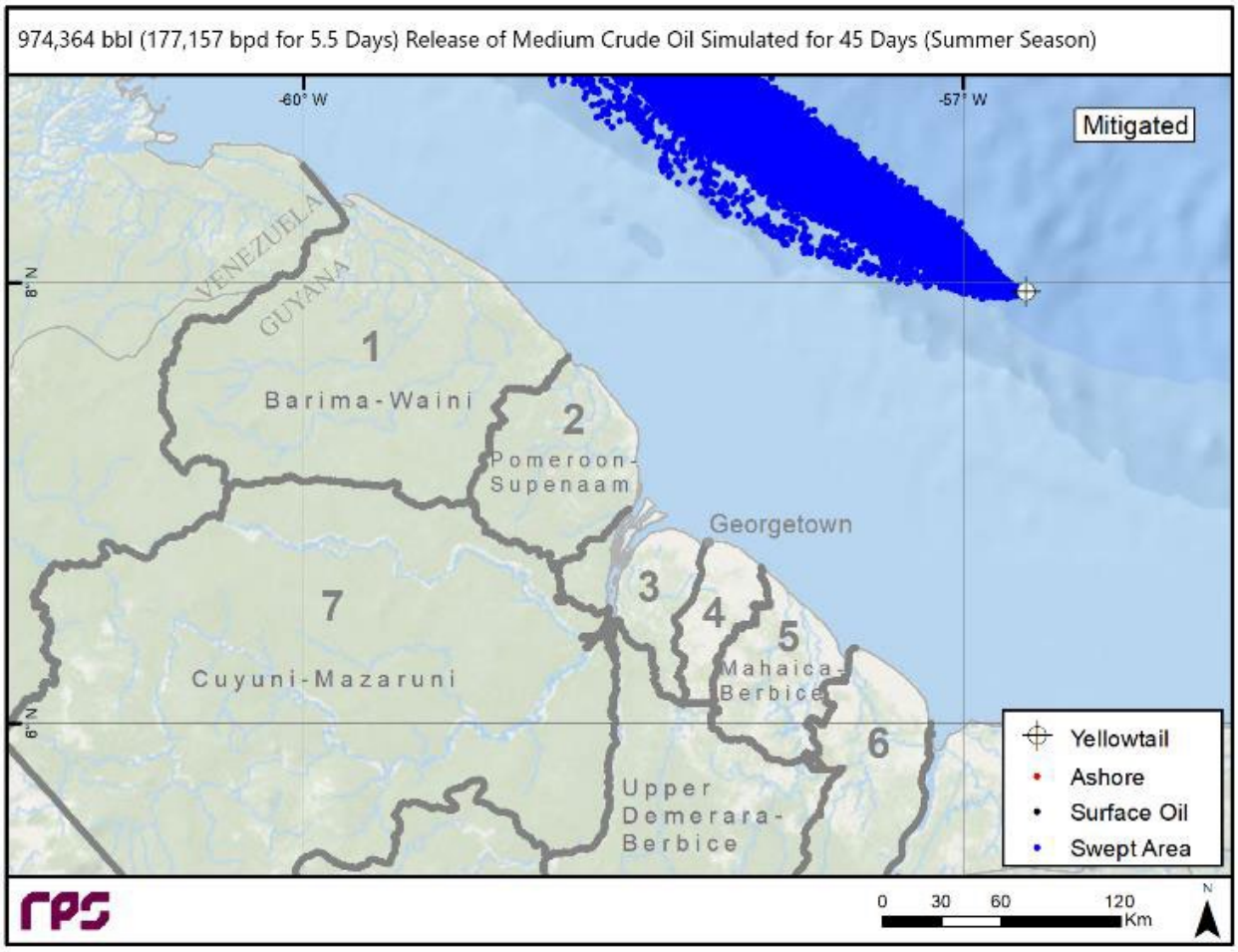


Figure 9.1-19b: (Zoomed In) Deterministic Map for Scenario 15—Predicted Transport after 45 Days from a Mitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil—Capped After 5.5 Days (Jun–Nov)

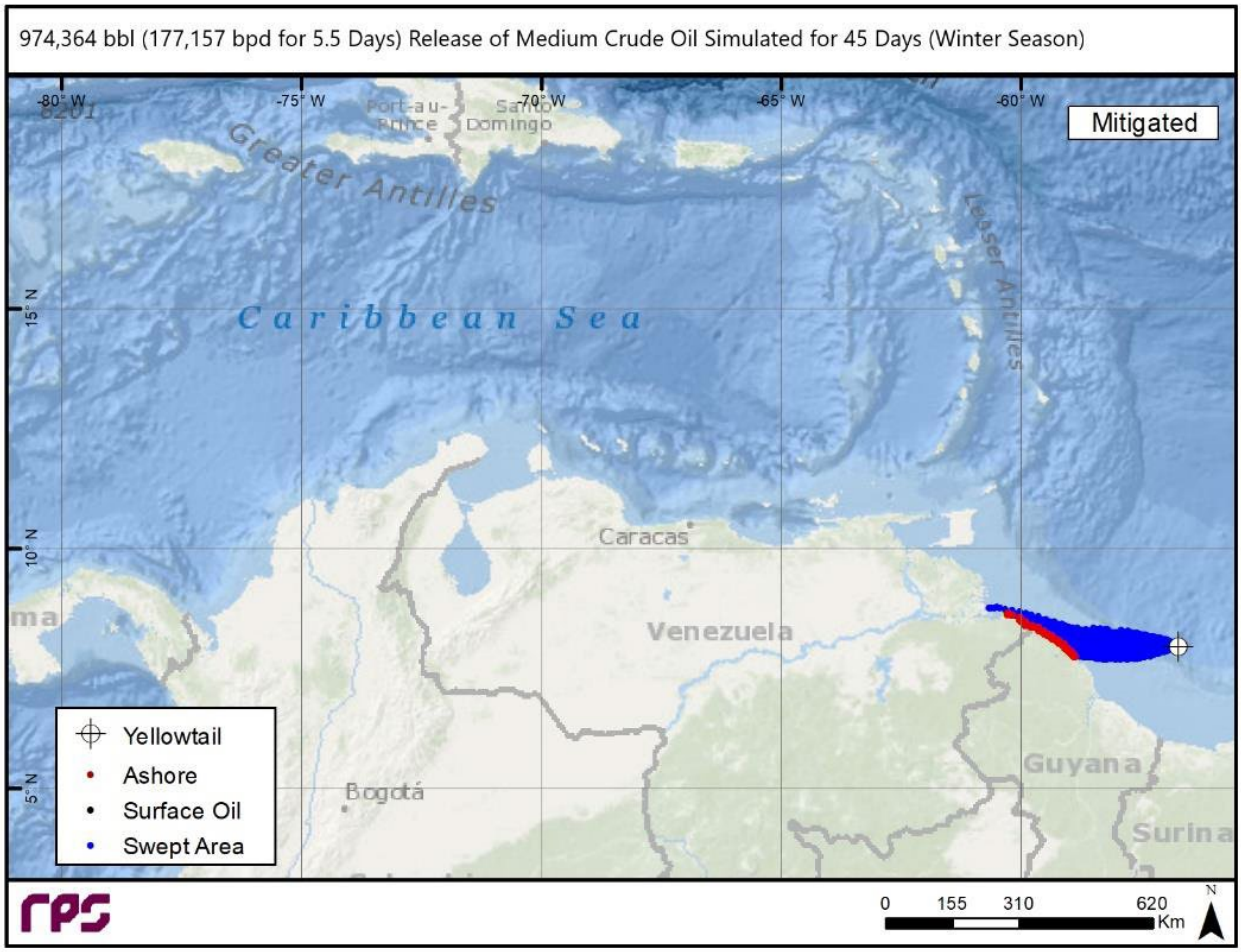


Figure 9.1-20a: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from a Mitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil—Capped After 5.5 Days (Dec–May)

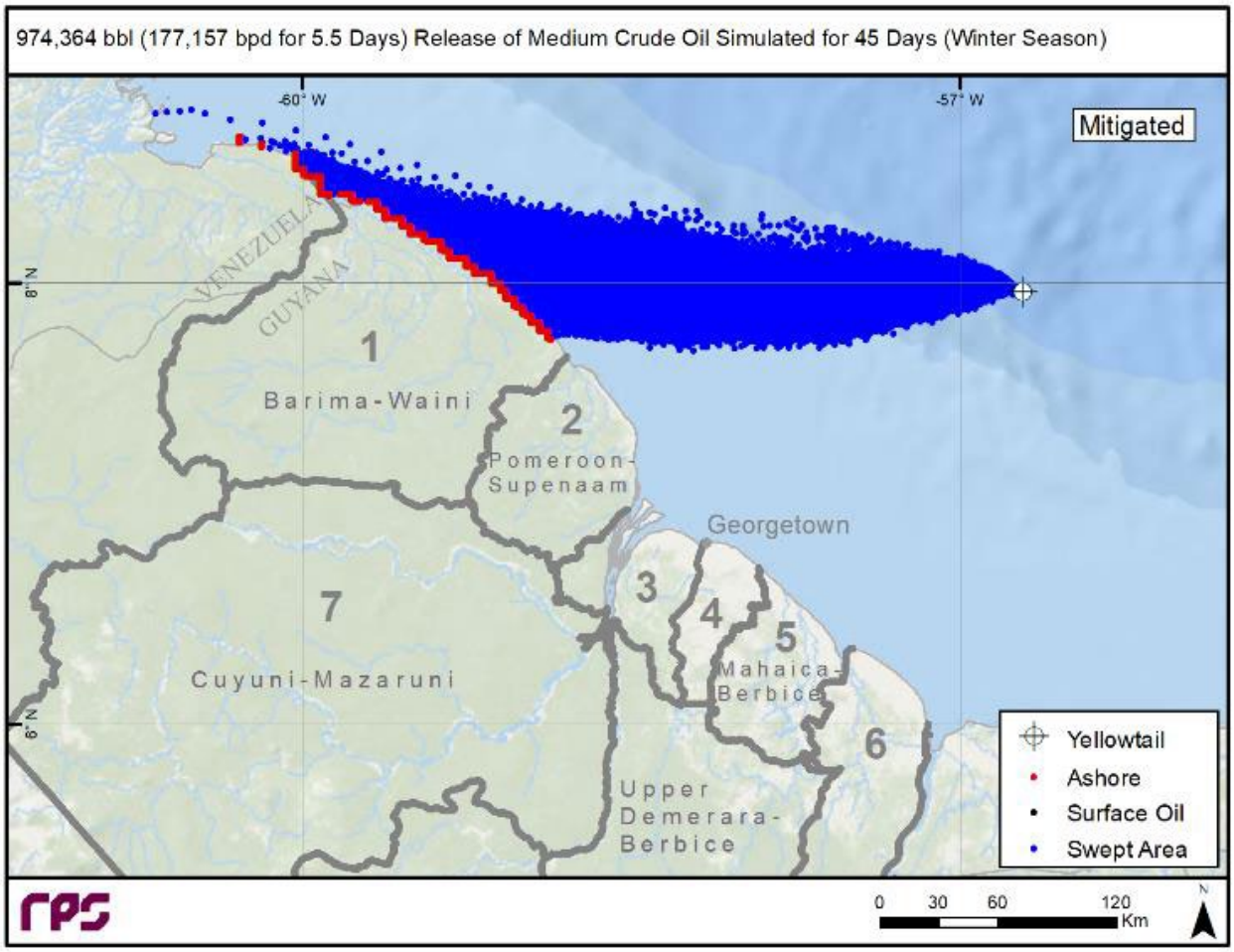


Figure 9.1-20b: (Zoomed In) Deterministic Map for Scenario 15—Predicted Transport after 45 Days from a Mitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil—Capped After 5.5 Days (Dec–May)

9.1.6. Coastal Sensitivity Mapping

Coastal sensitivity mapping was completed for coastal areas identified in the oil spill modeling as having the potential for oiling as a result of any of the deterministic modeling of unmitigated marine oil spill scenarios. The coastal sensitivity mapping consisted of initial desktop-based research, followed by field verification in specific areas (Regions 1–6 in Guyana,[3] and Trinidad and Tobago). The mapping included characterization of the following resources:

- Environmental—protected areas, mangroves, shoreline types, seagrass beds, coral reefs, coastal fish habitats, coastal bird habitats, and other sensitive habitats
- Socioeconomic—coastal and/or indigenous communities (e.g., locations, demographics, and socioeconomic characteristics), ecosystem services (type, beneficiaries, value of services to beneficiaries, habitats, and resources), shoreline- and coastal-dependent commercial and artisanal activities (e.g., fishing, foraging, hunting, agriculture, grazing, and transportation), industrial activities and infrastructure (e.g., water intake facilities, ports), and traditional cultural practices.

The coastal sensitivity maps are provided in Appendix O, Coastal Sensitivity Maps. The information presented in the maps will enable EEPGL to prioritize the mobilization of emergency response resources (personnel and equipment) to those areas most sensitive to a spill. The coastal sensitivity maps are provided in Appendix O, Coastal Sensitivity Maps. Maps are provided for each country (or portion of a country) where deterministic modeling of an unmitigated loss-of-well-control event for at least one of the two WCD scenarios (either season) predicted shoreline oiling.[4] The maps are intended to enable EEPGL to prioritize the mobilization of emergency response resources (personnel and equipment) to those areas most sensitive to a spill. Additionally, as outlined in OSRP Section 5.6.2 (included in Volume III of the EIA), Geographical Strategic Response Maps have also been developed to define the equipment needs in specific coastline areas of portions of the geographic response area, considering sensitive areas, access points, and likely response actions. Examples of these Geographical Strategic Response Maps are provided in OSRP Appendix E.

To aid in comparing the results of oil spill modeling to coastal sensitivity data, the following figures show the results of deterministic modeling of an unmitigated loss of well control for both WCD scenarios (both seasons), each overlaid with the relevant coastal sensitivity map “tiles” included in Appendix O:

- Guyana: Figures 9.1-21a and 9.1-21b
- Trinidad and Tobago: Figures 9.1-22a and 9.1-22b
- Venezuela: Figures 9.1-23a and 9.1-23b
- Grenada: Figures 9.1-24a and 9.1-24b
- St. Vincent and The Grenadines: Figures 9.1-25a and 9.1-25b

[3] Although oil spill modeling indicates Regions 1 and 2 are the only Guyanese region with the potential to have a coastline impacted by an unmitigated subsea release from a loss-of-well-control event, coastal sensitivity data were collected for Regions 1 through 6 as part of Liza Phase 1 post permit studies.

[4] None of the modeling predicted shoreline oiling of Barbados from an unmitigated loss-of-well-control event, but coastal sensitivity maps were prepared since it is in close proximity to other countries with predicted shoreline oiling.

- Bonaire: Figures 9.1-26a and 9.1-26b
- Curaçao: Figures 9.1-27a and 9.1-27b
- Aruba: Figures 9.1-28a and 9.1-28b
- Dominican Republic: Figures 9.1-29a and 9.1-29b
- Haiti: Figures 9.1-30a and 9.1-30b
- Jamaica: Figures 9.1-31a and 9.1-31b
- Colombia: Figures 9.1-32a and 9.1-32b

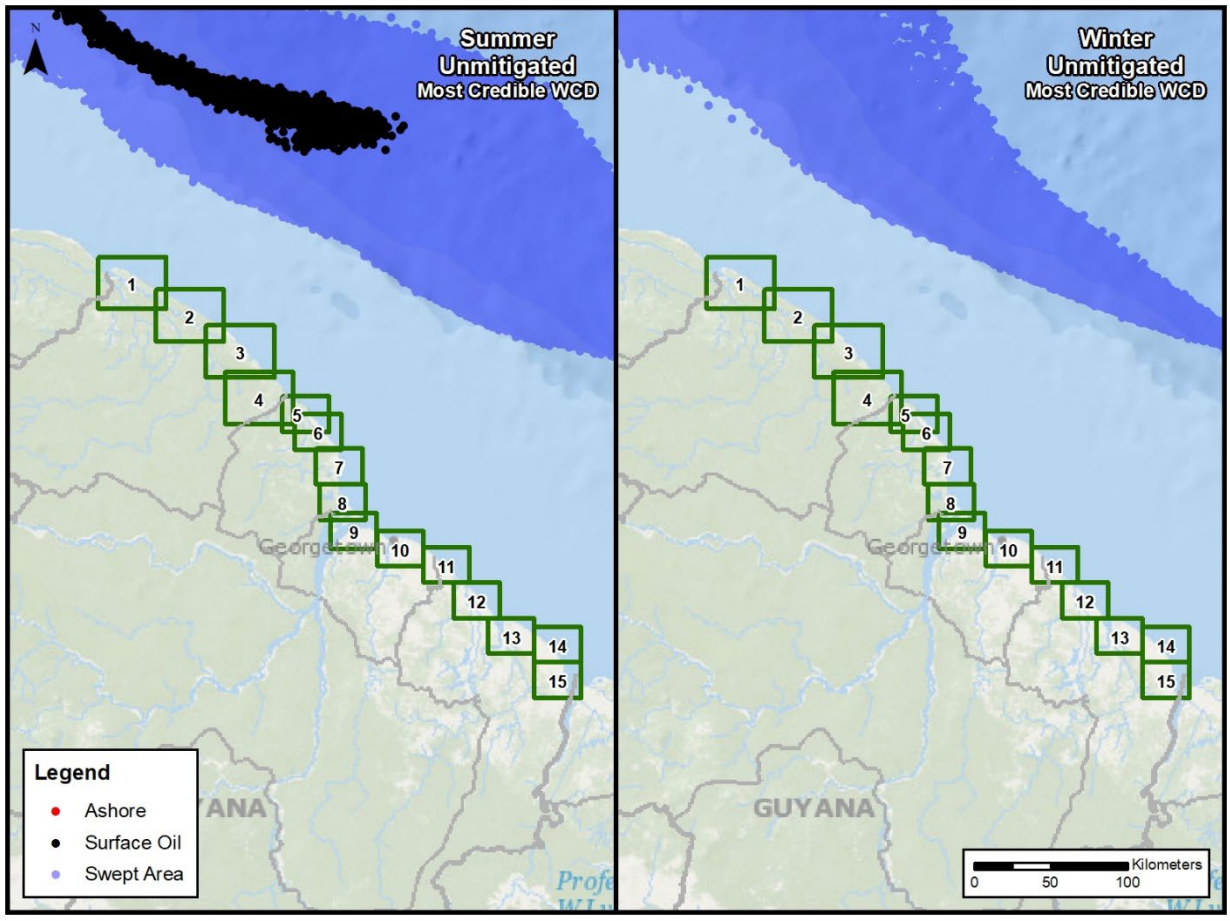


Figure 9.1-21a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Guyana

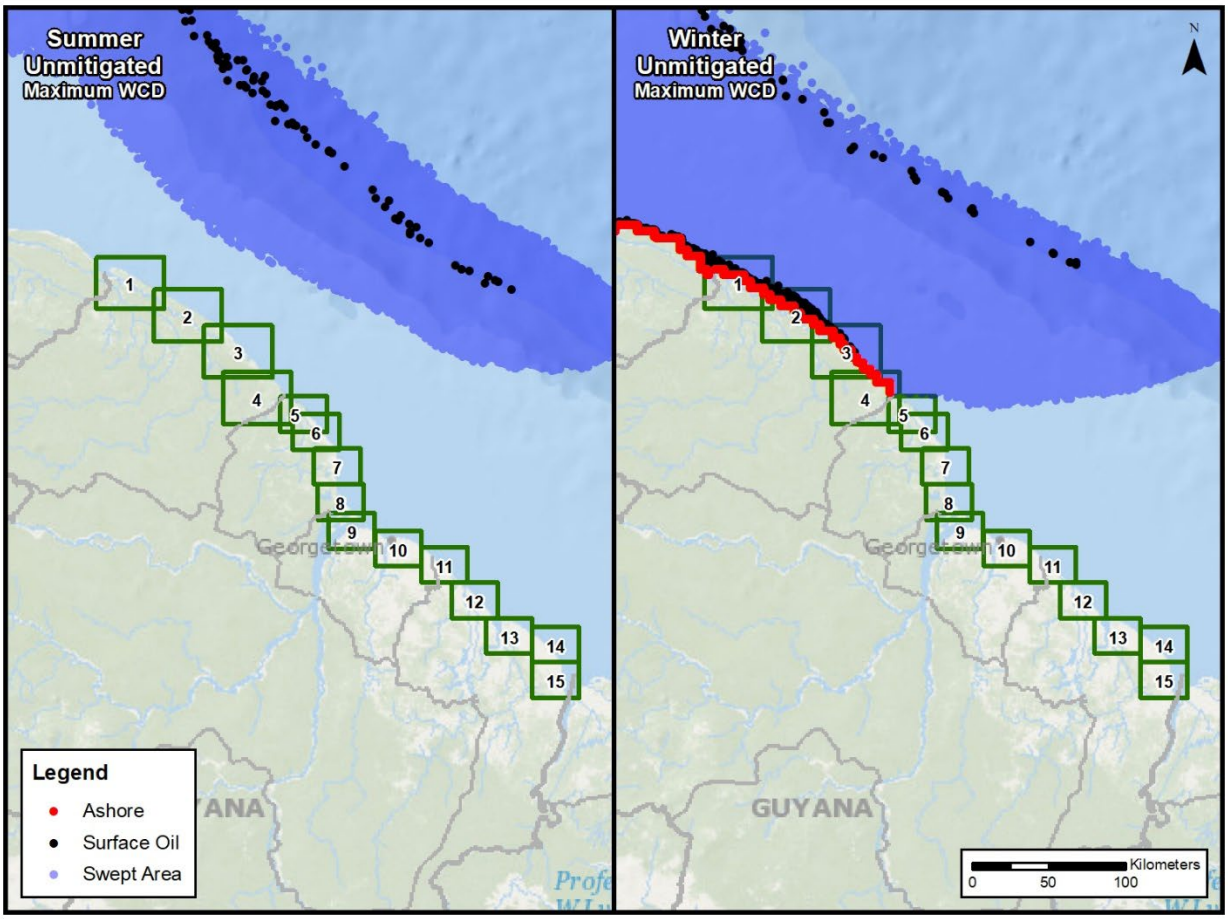


Figure 9.1-21b: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Guyana

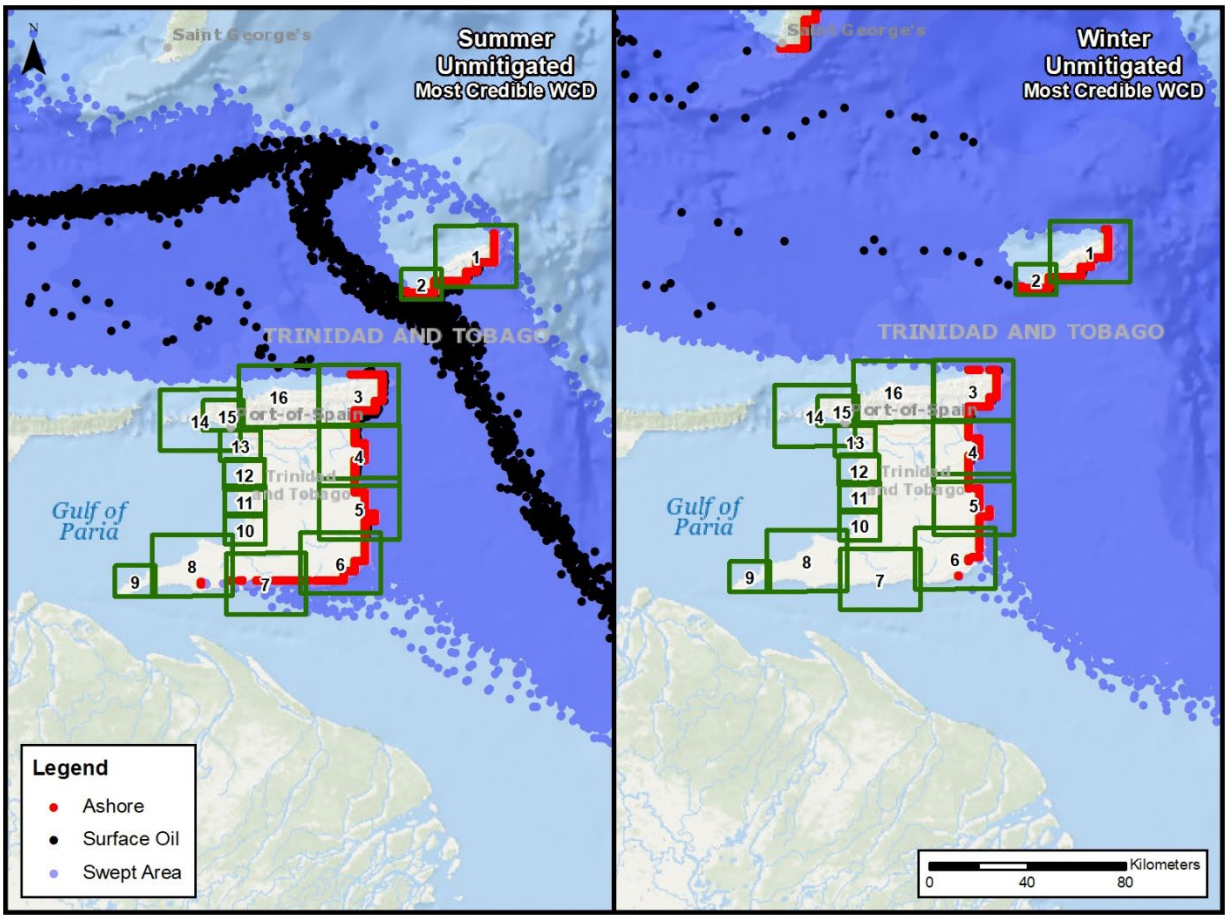


Figure 9.1-22a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from an Unmitigated 88,728 BPD (28,345 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Trinidad and Tobago

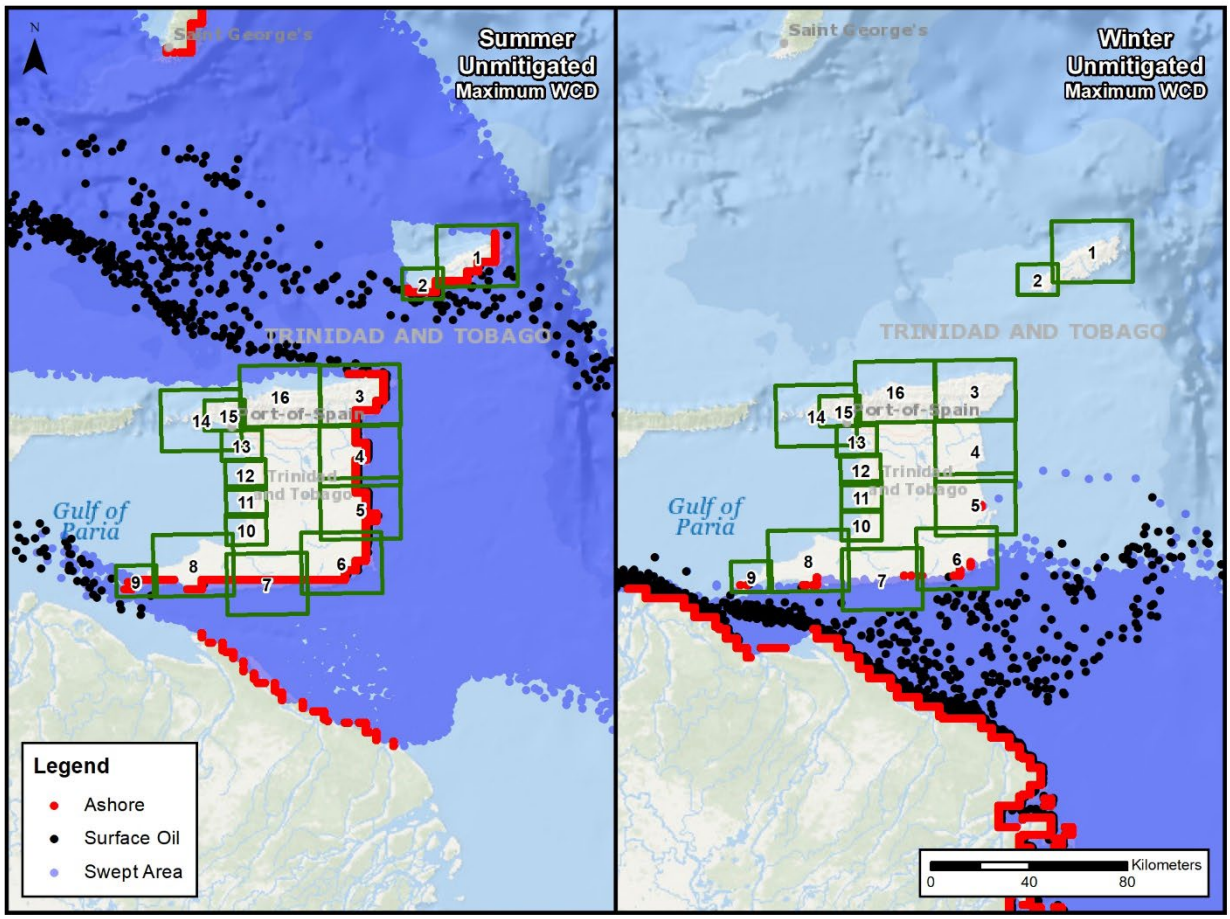


Figure 9.1-22b: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Trinidad and Tobago

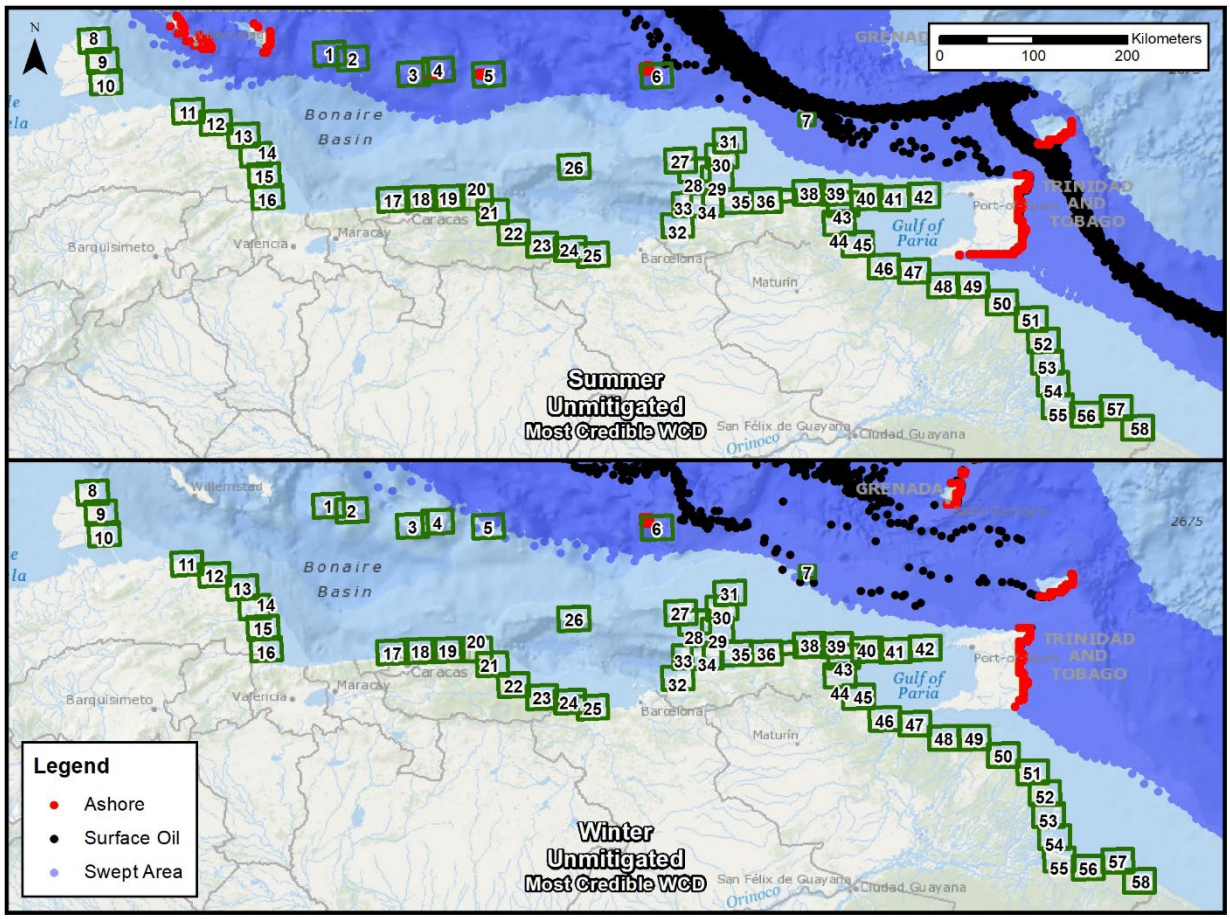


Figure 9.1-23a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Venezuela

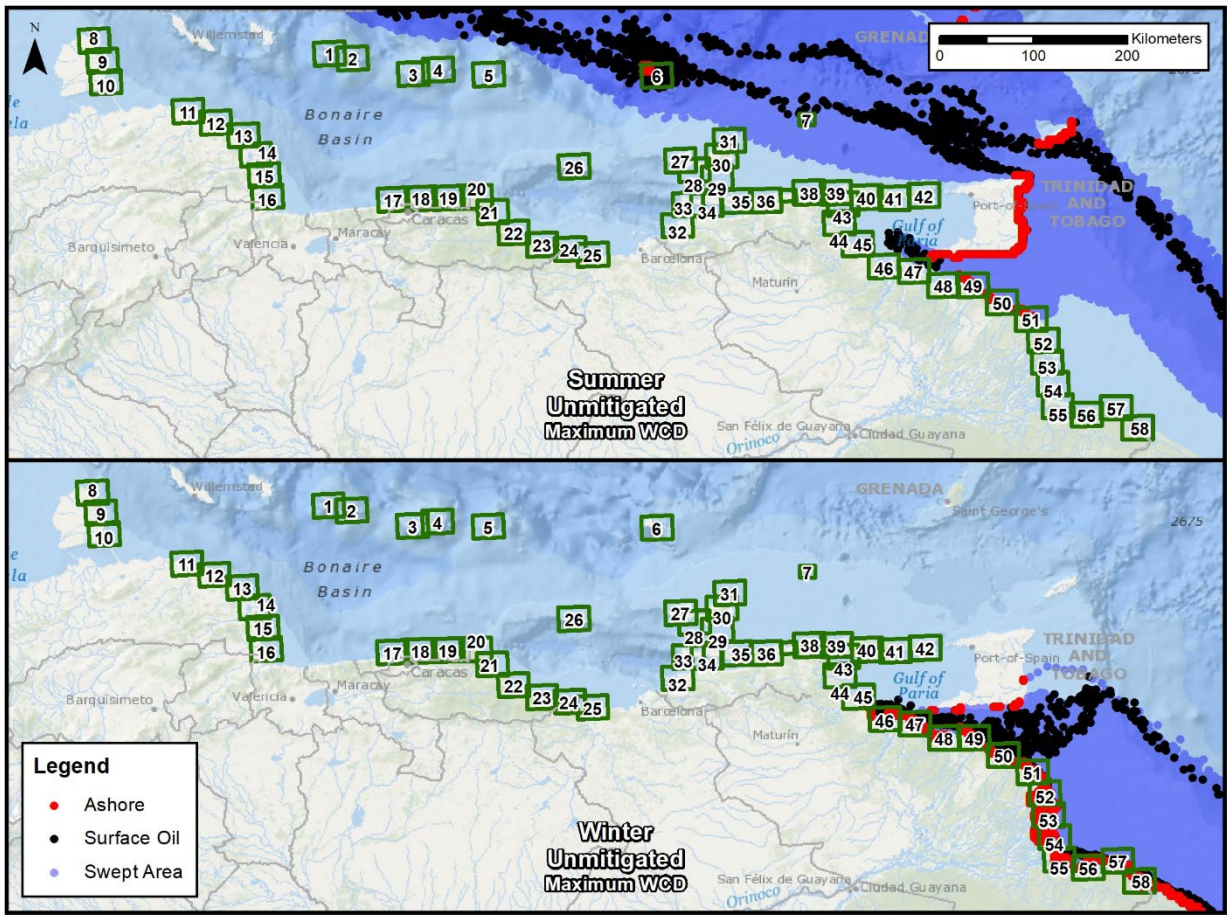


Figure 9.1-23b: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Venezuela

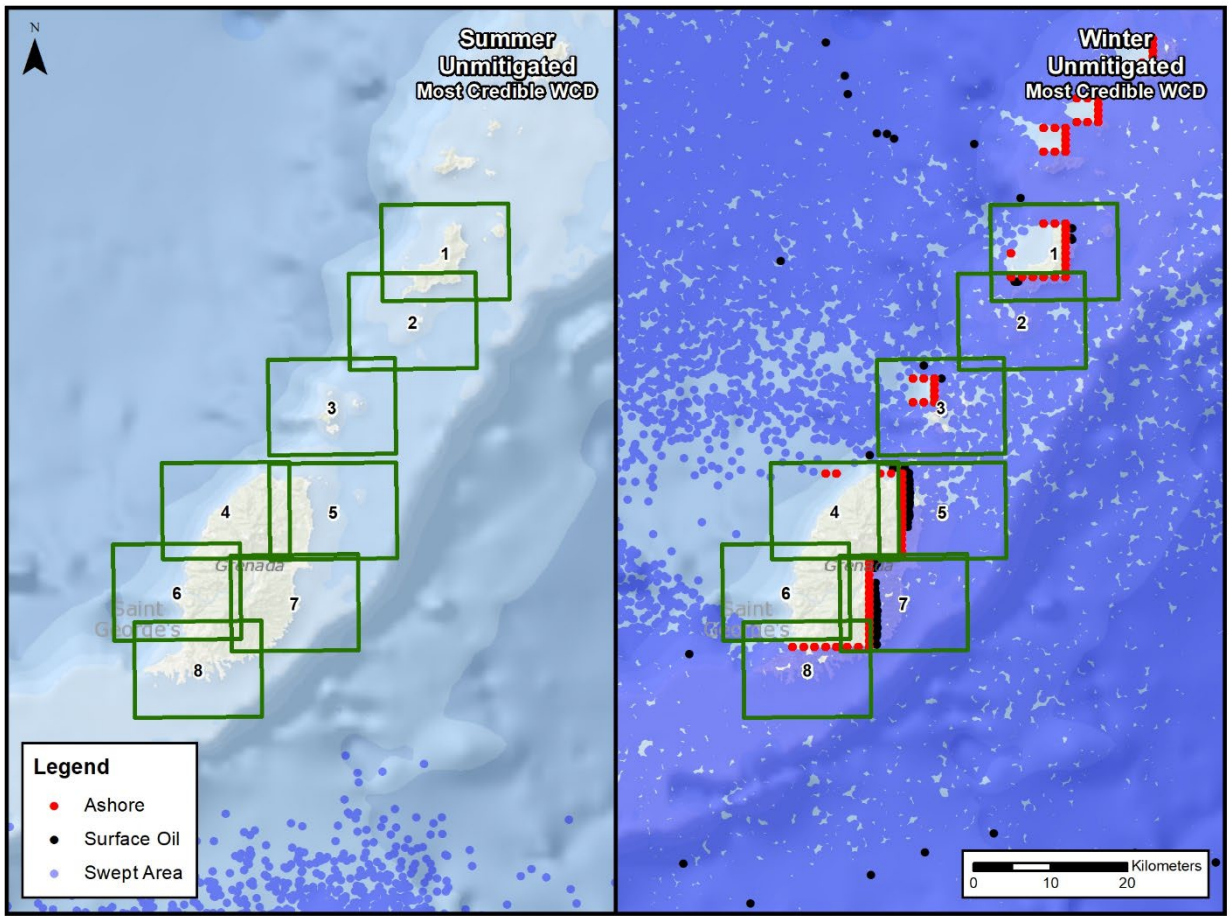


Figure 9.1-24a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Grenada

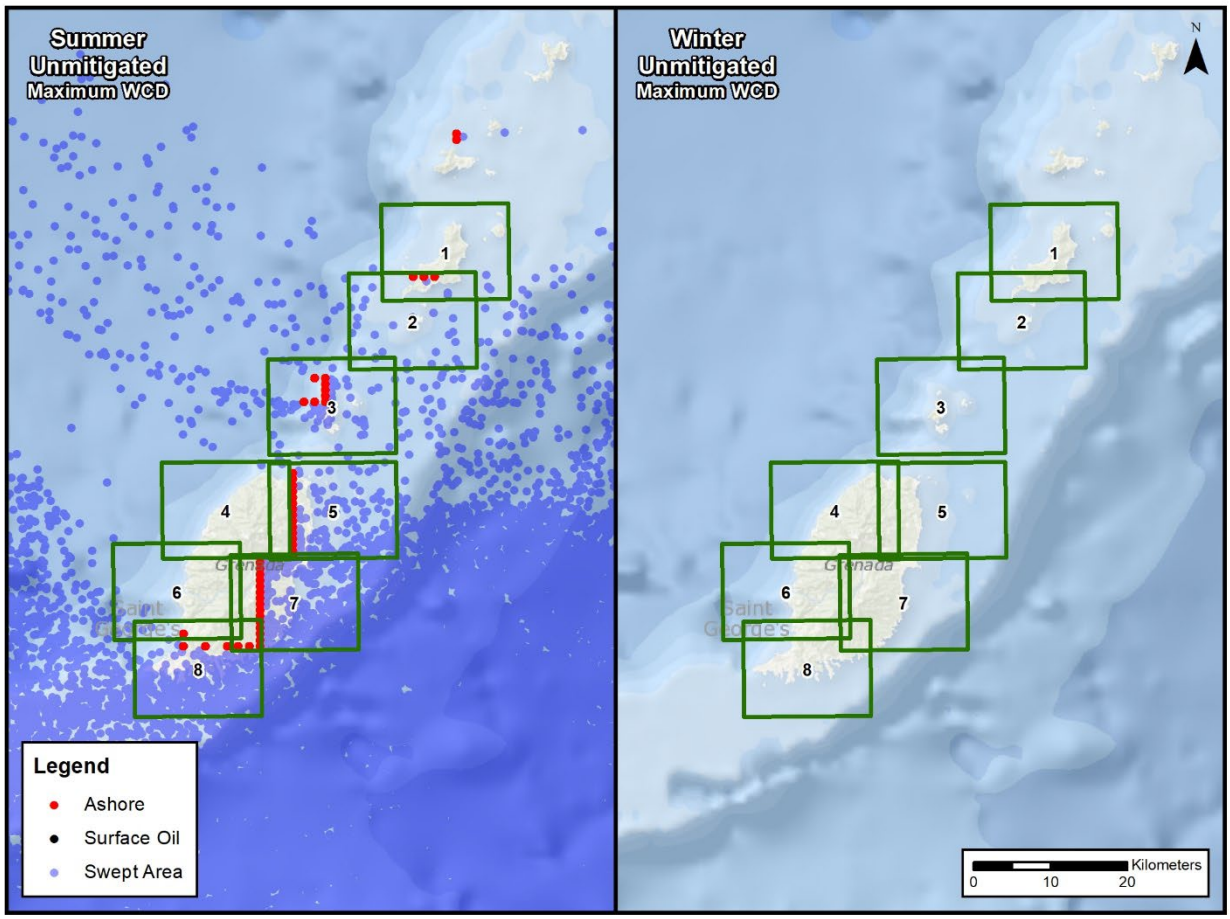


Figure 9.1-24b: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Grenada

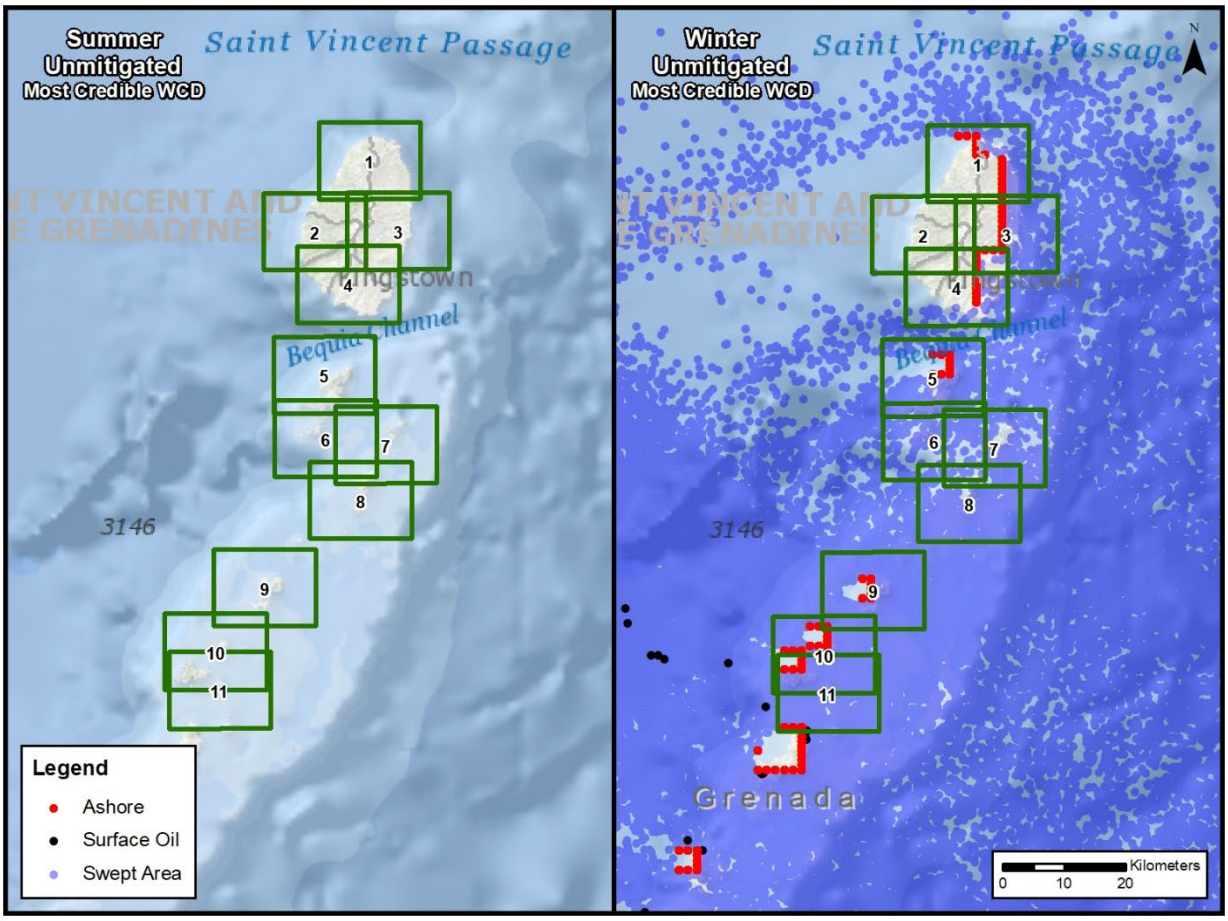


Figure 9.1-25a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for St. Vincent and The Grenadines

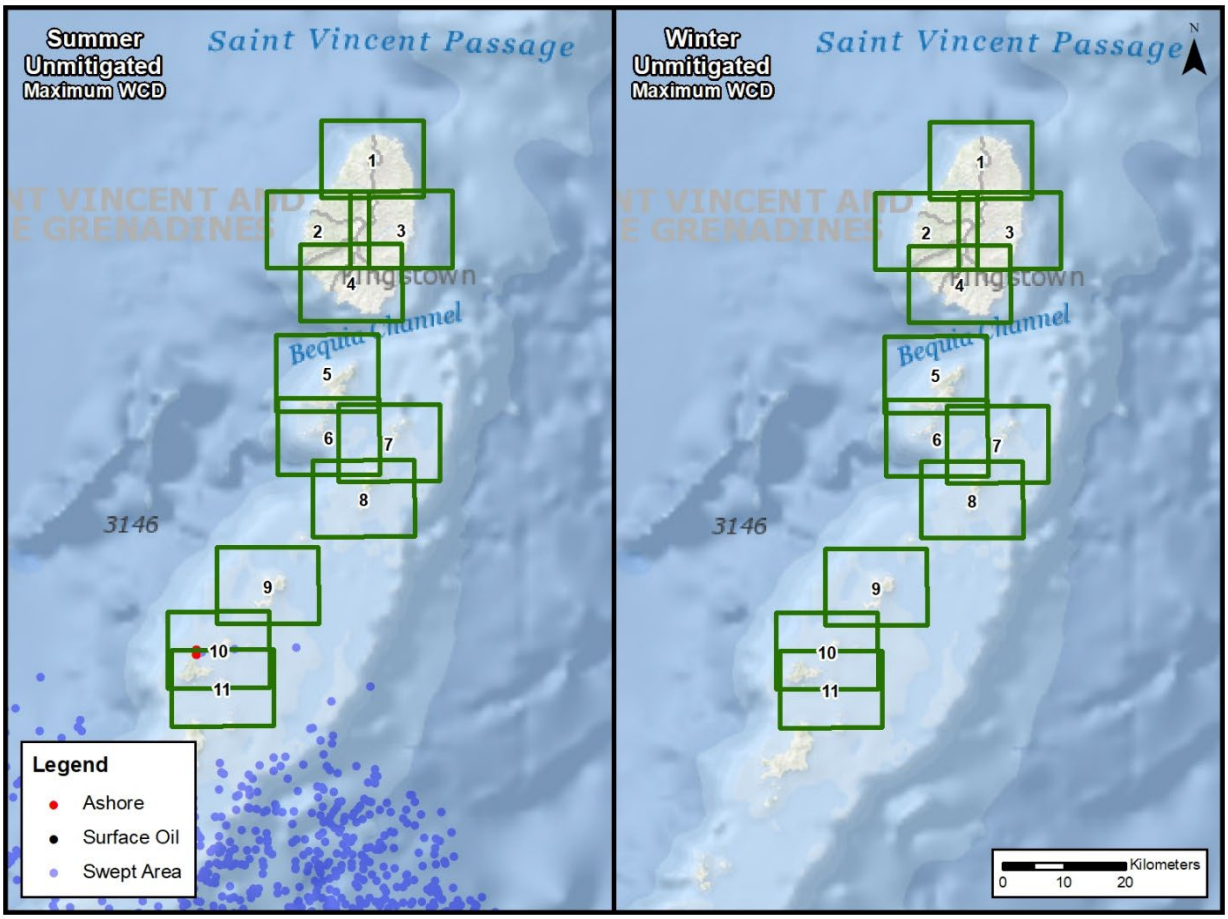


Figure 9.1-25b: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for St. Vincent and The Grenadines

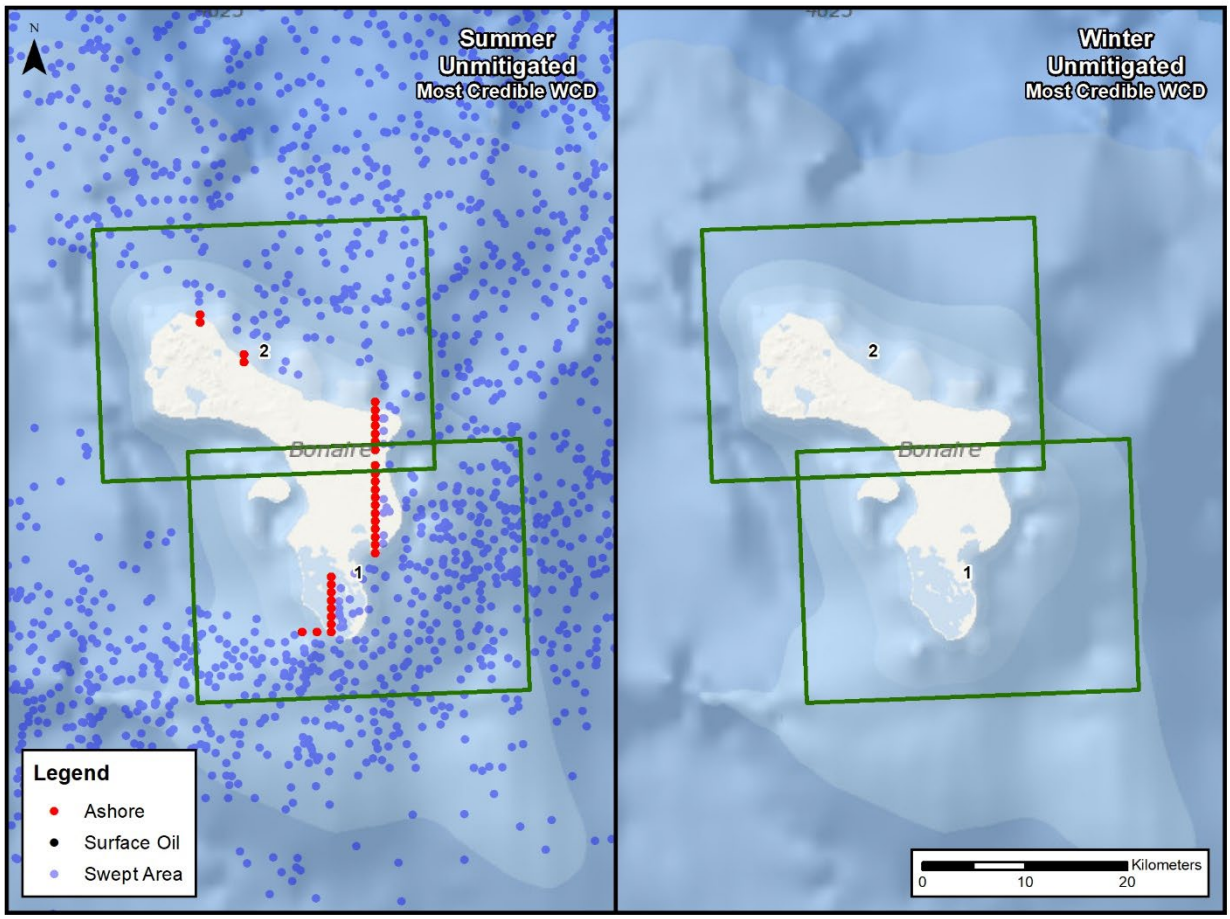


Figure 9.1-26a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Bonaire

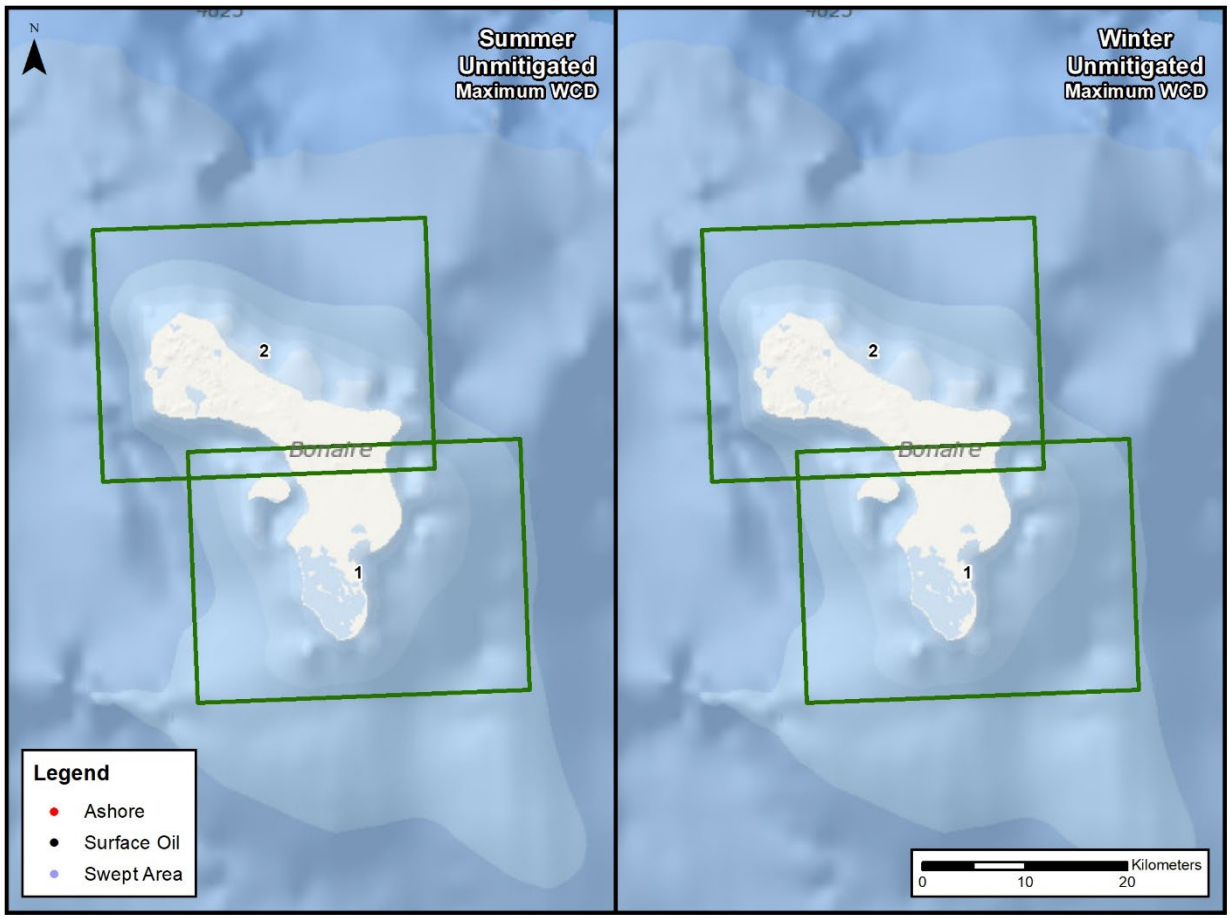


Figure 9.1-26b: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Bonaire

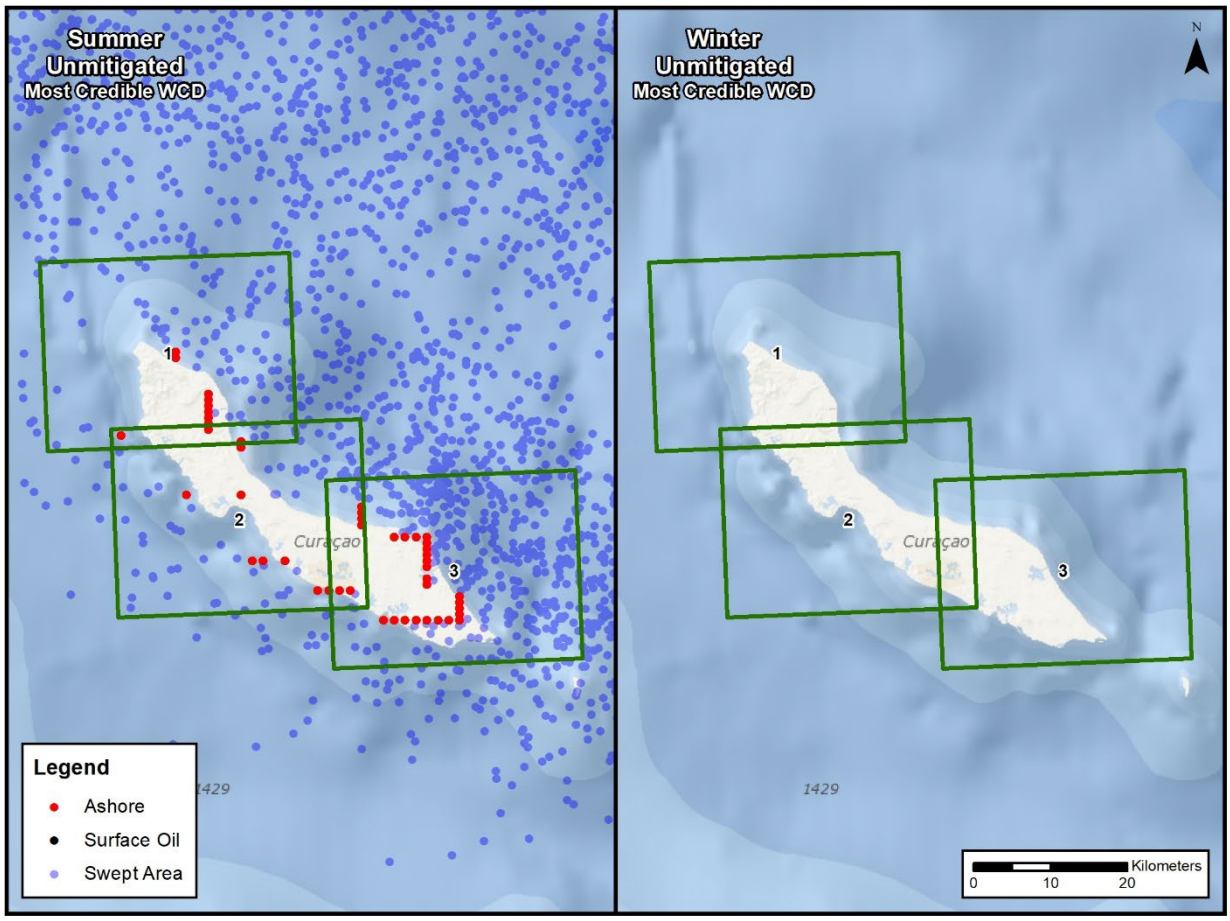


Figure 9.1-27a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Curaçao

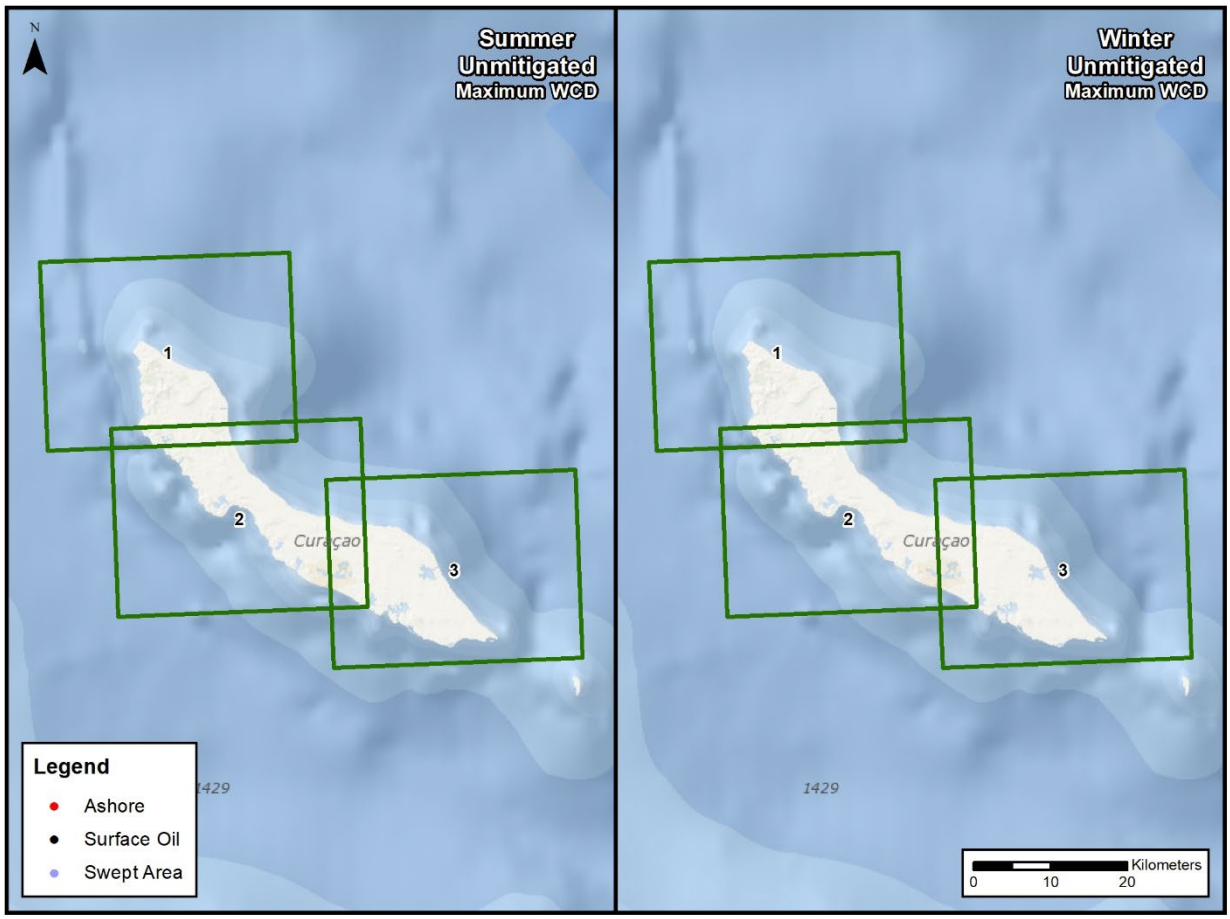


Figure 9.1-27b: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Curaçao

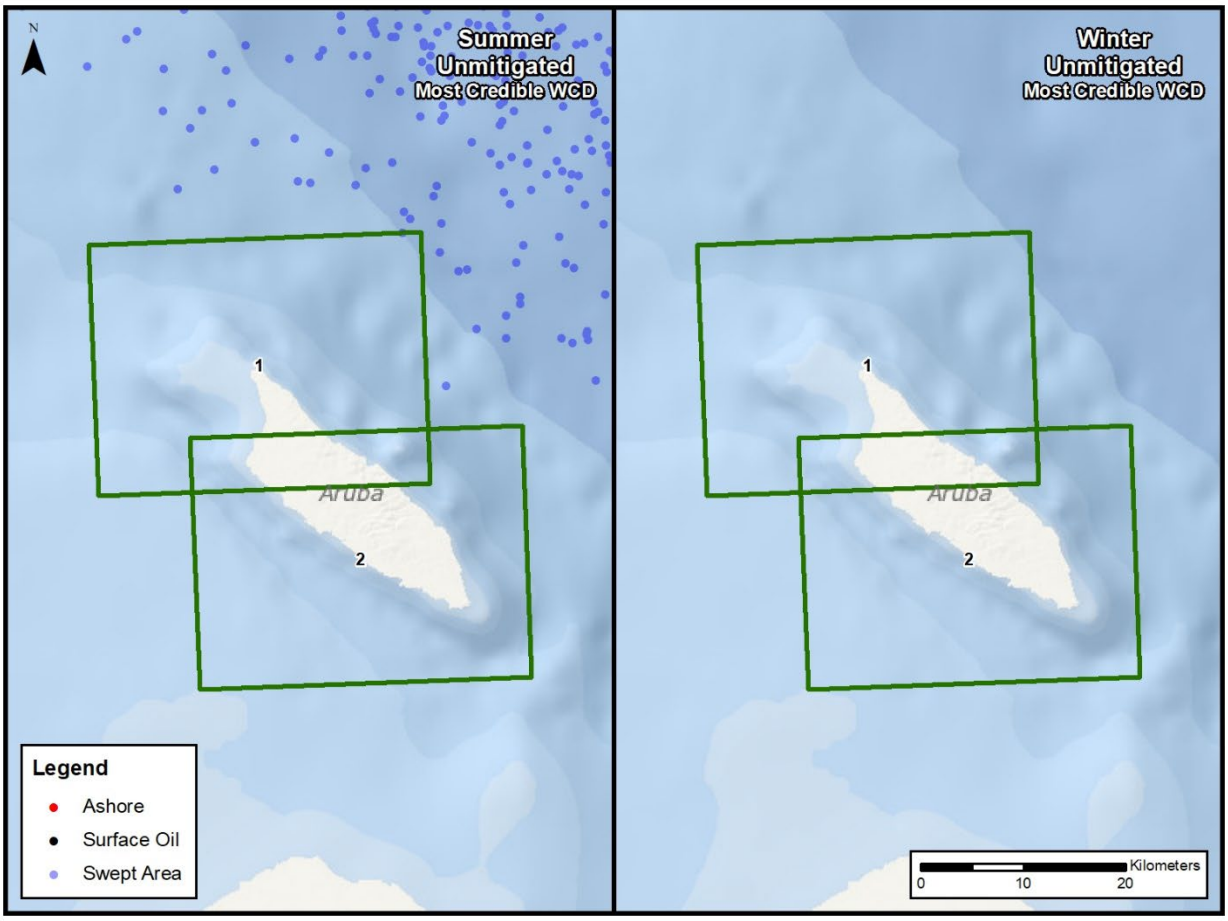


Figure 9.1-28a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Aruba

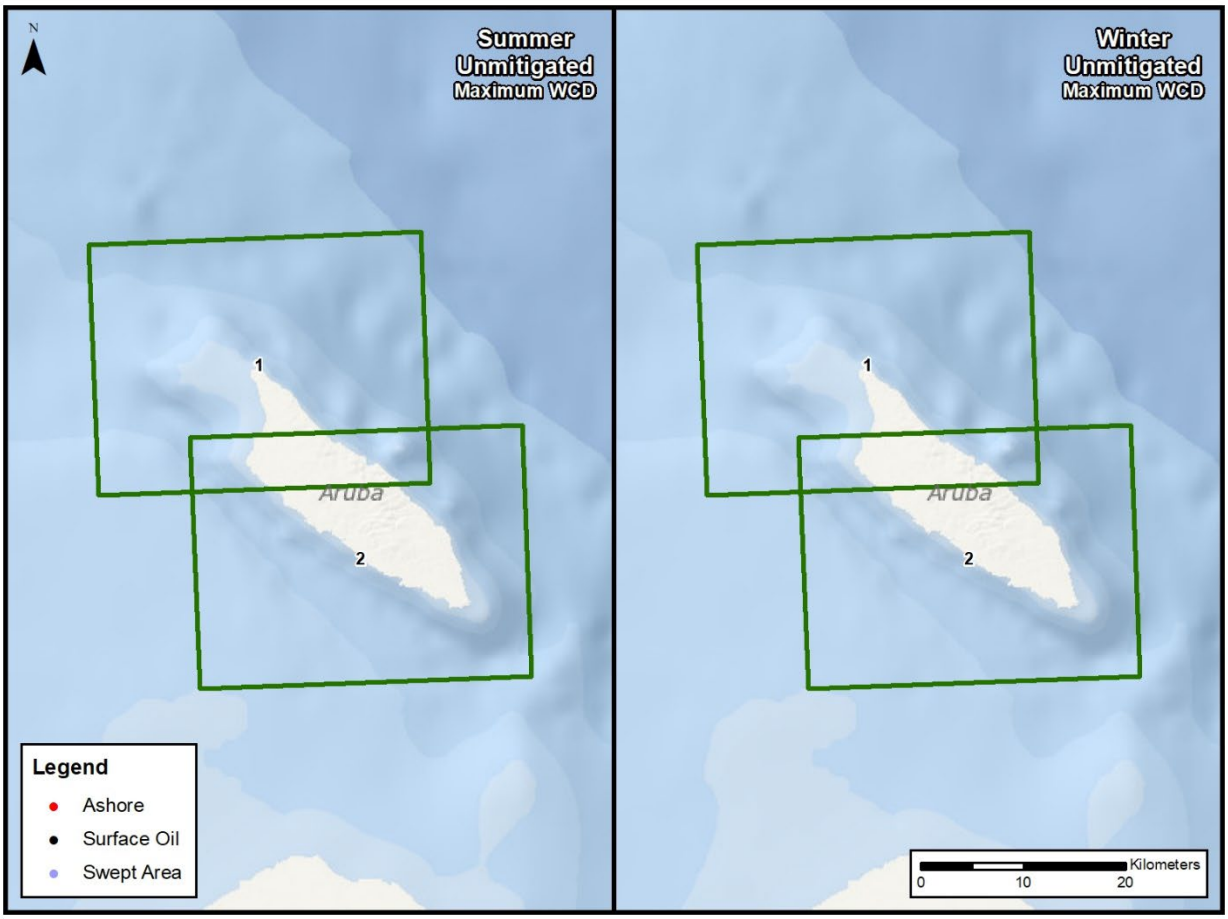


Figure 9.1-28b: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Aruba

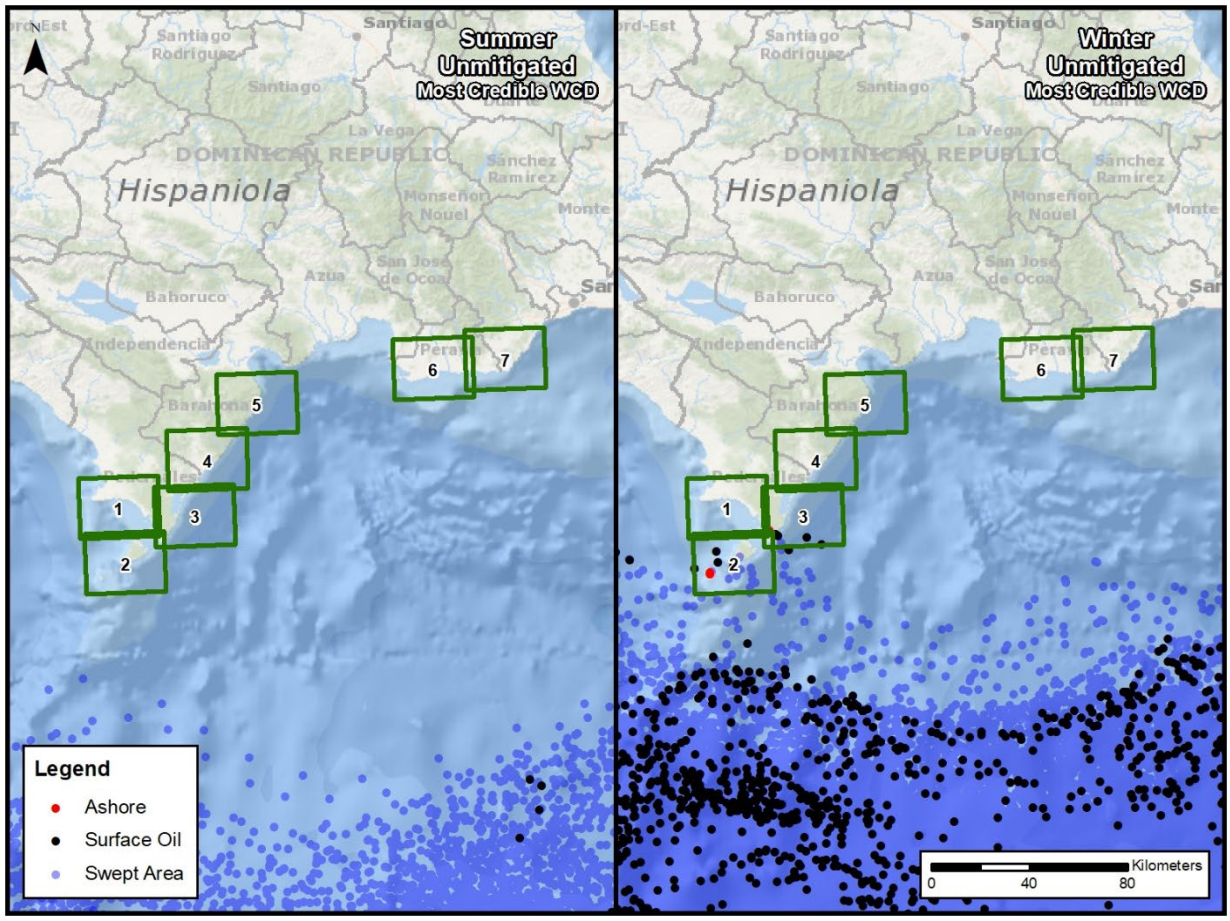


Figure 9.1-29a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Dominican Republic

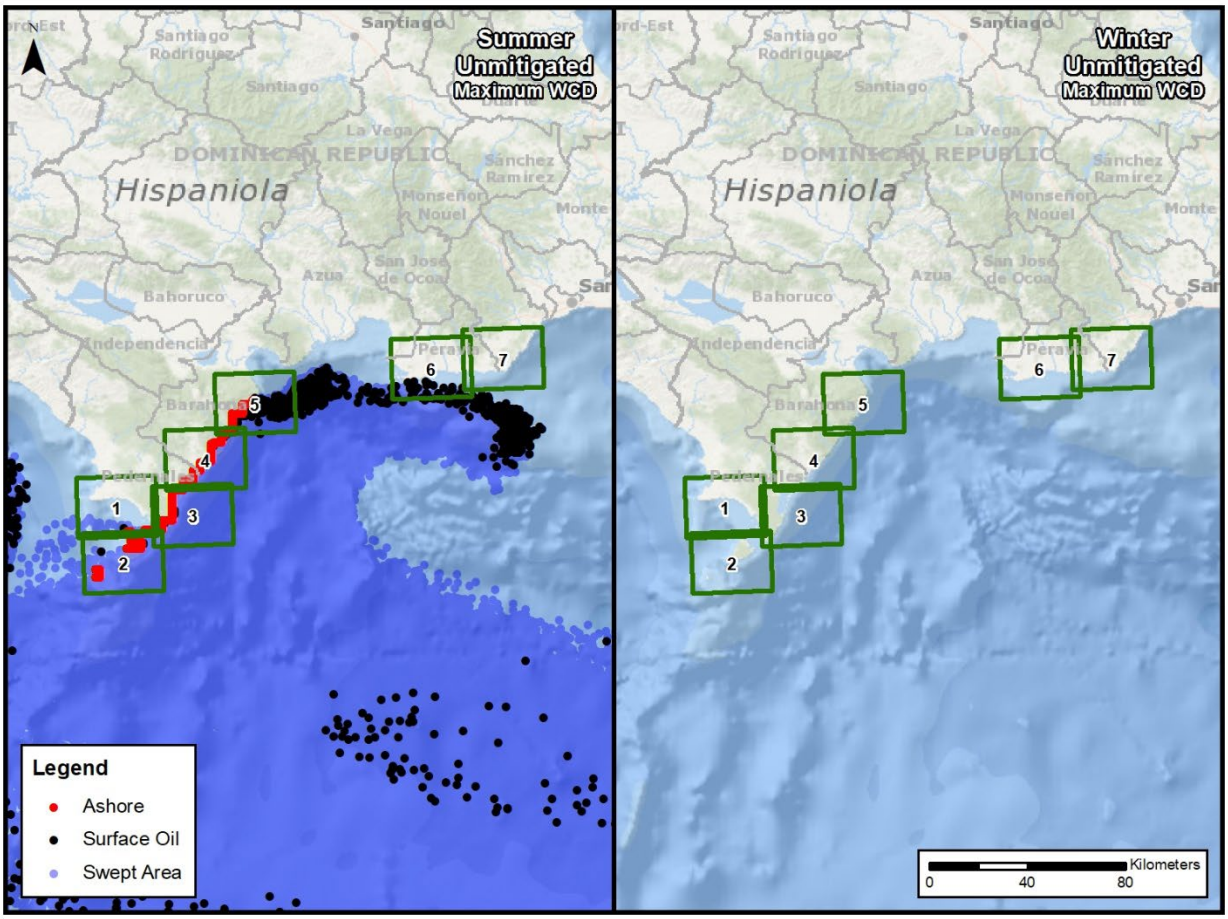


Figure 9.1-29b: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Dominican Republic

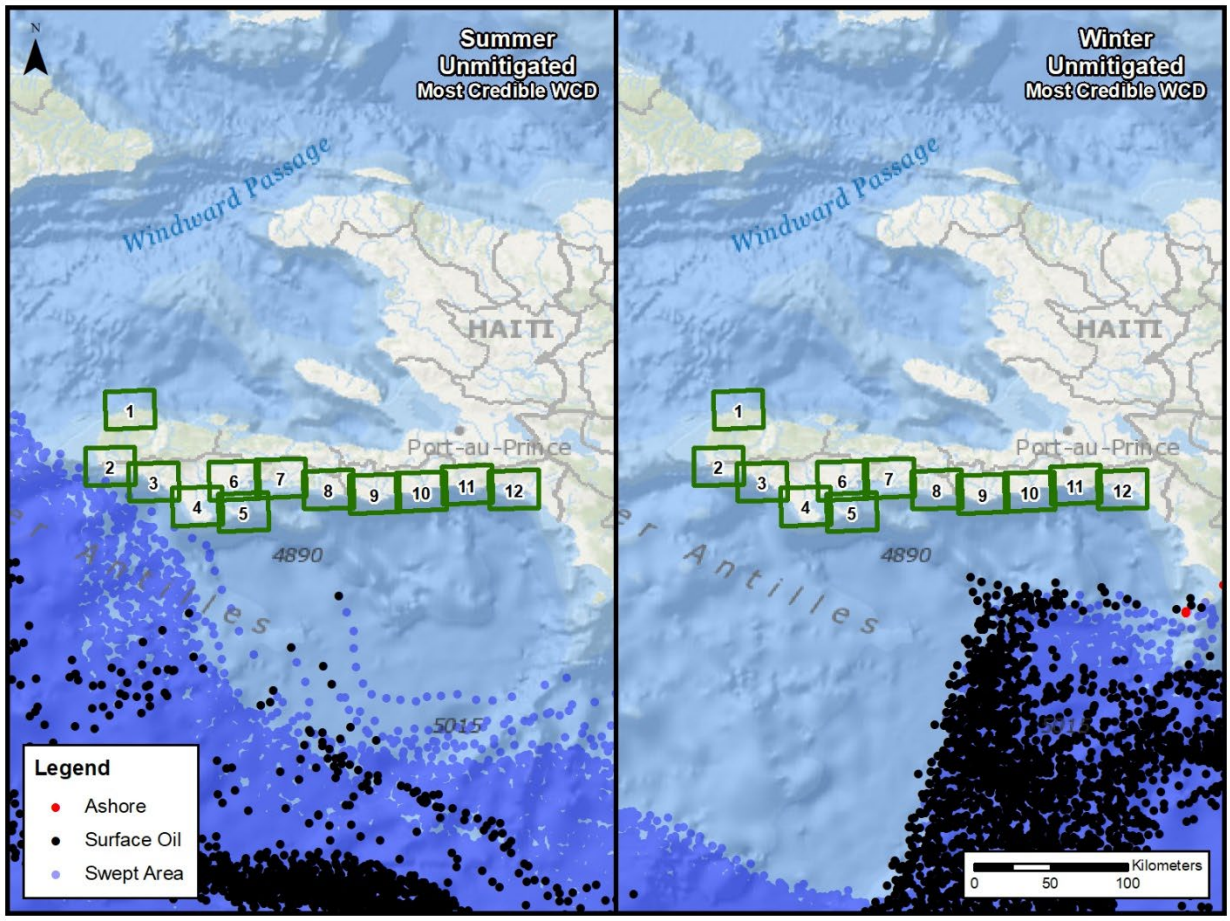


Figure 9.1-30a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Haiti

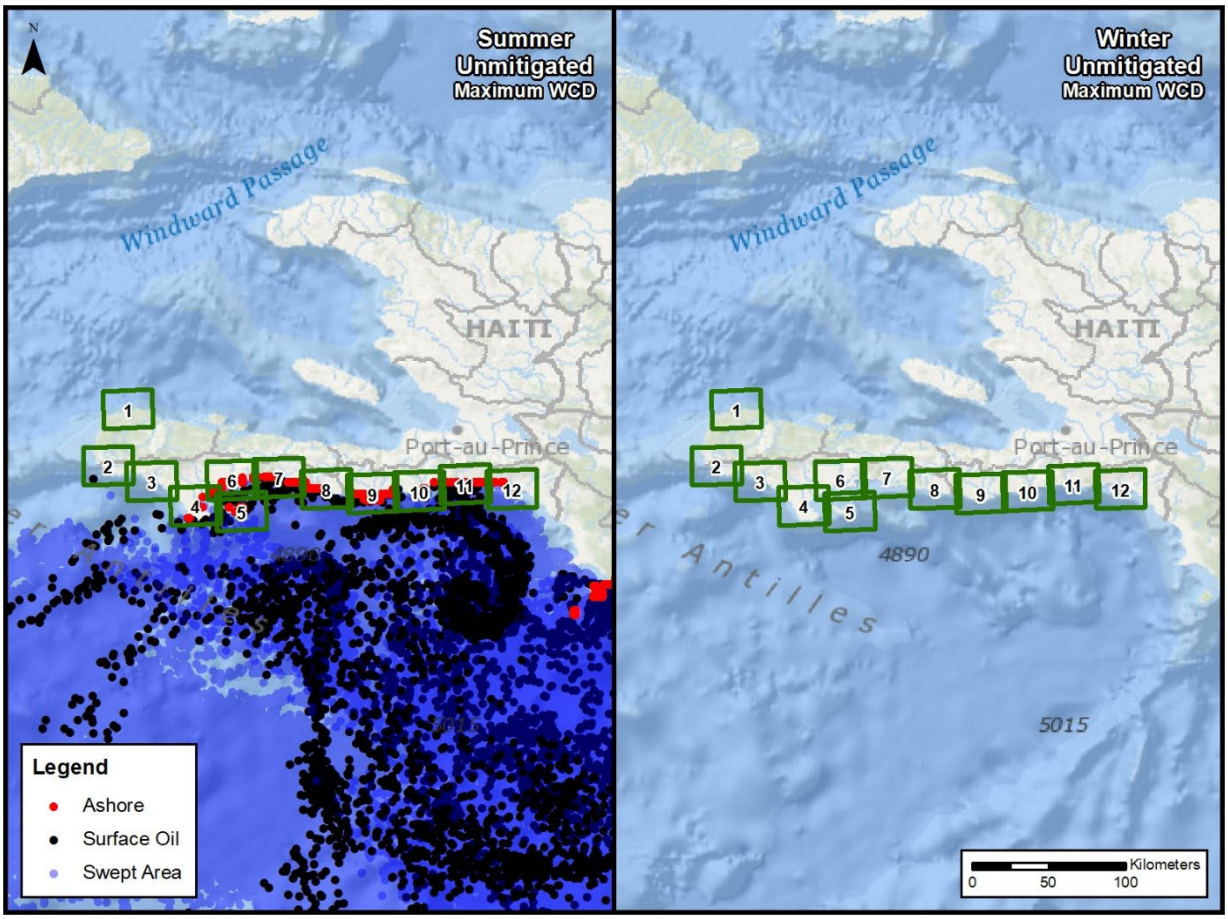


Figure 9.1-30b: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Haiti

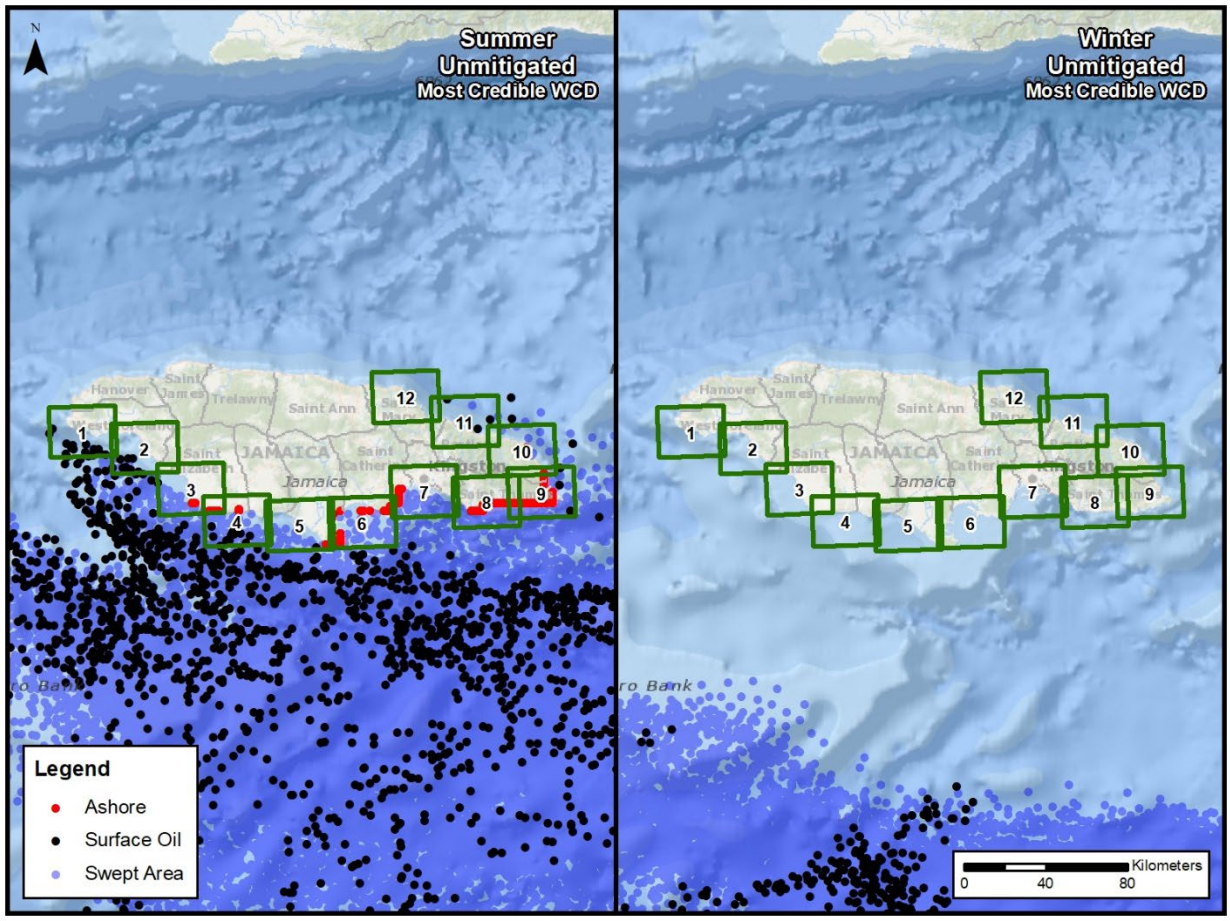


Figure 9.1-31a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Jamaica

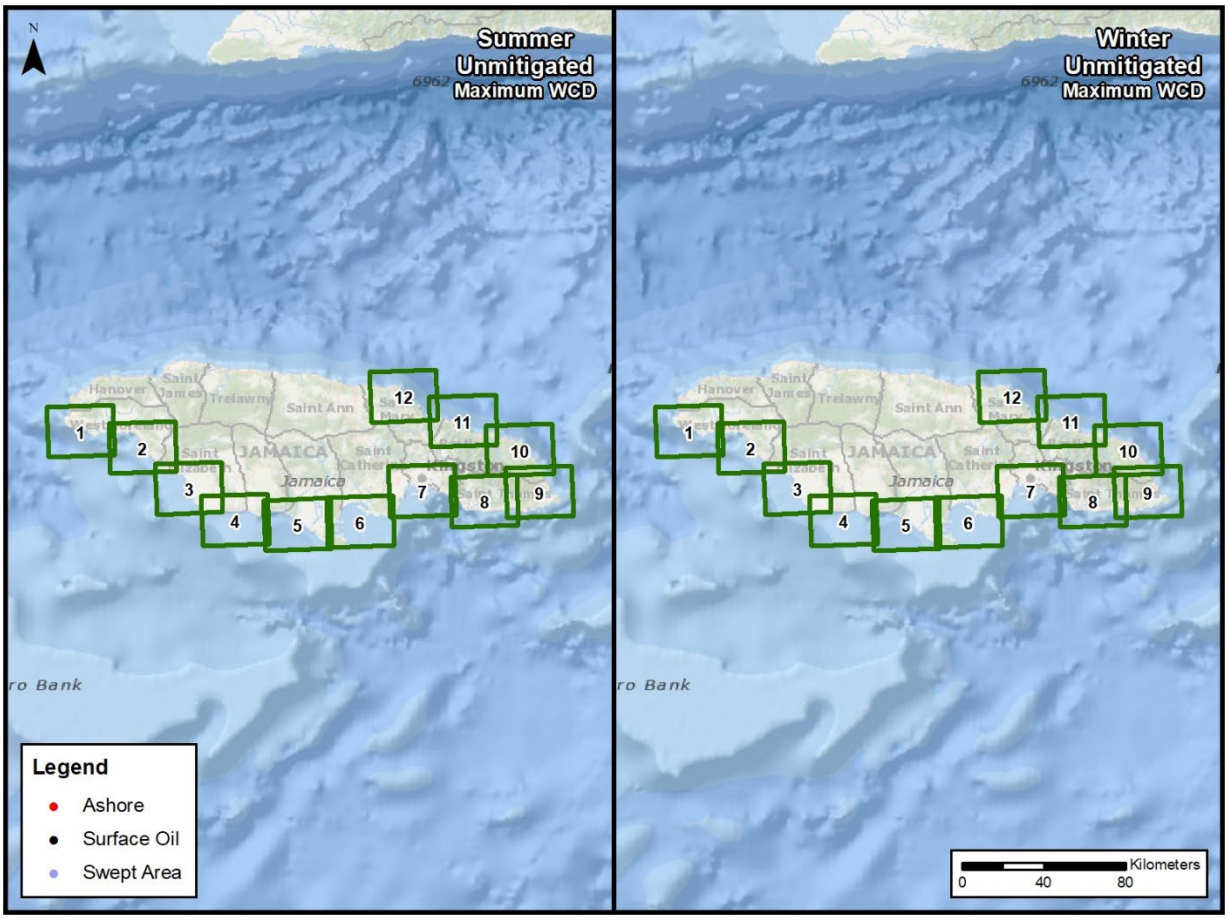


Figure 9.1-31b: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Jamaica

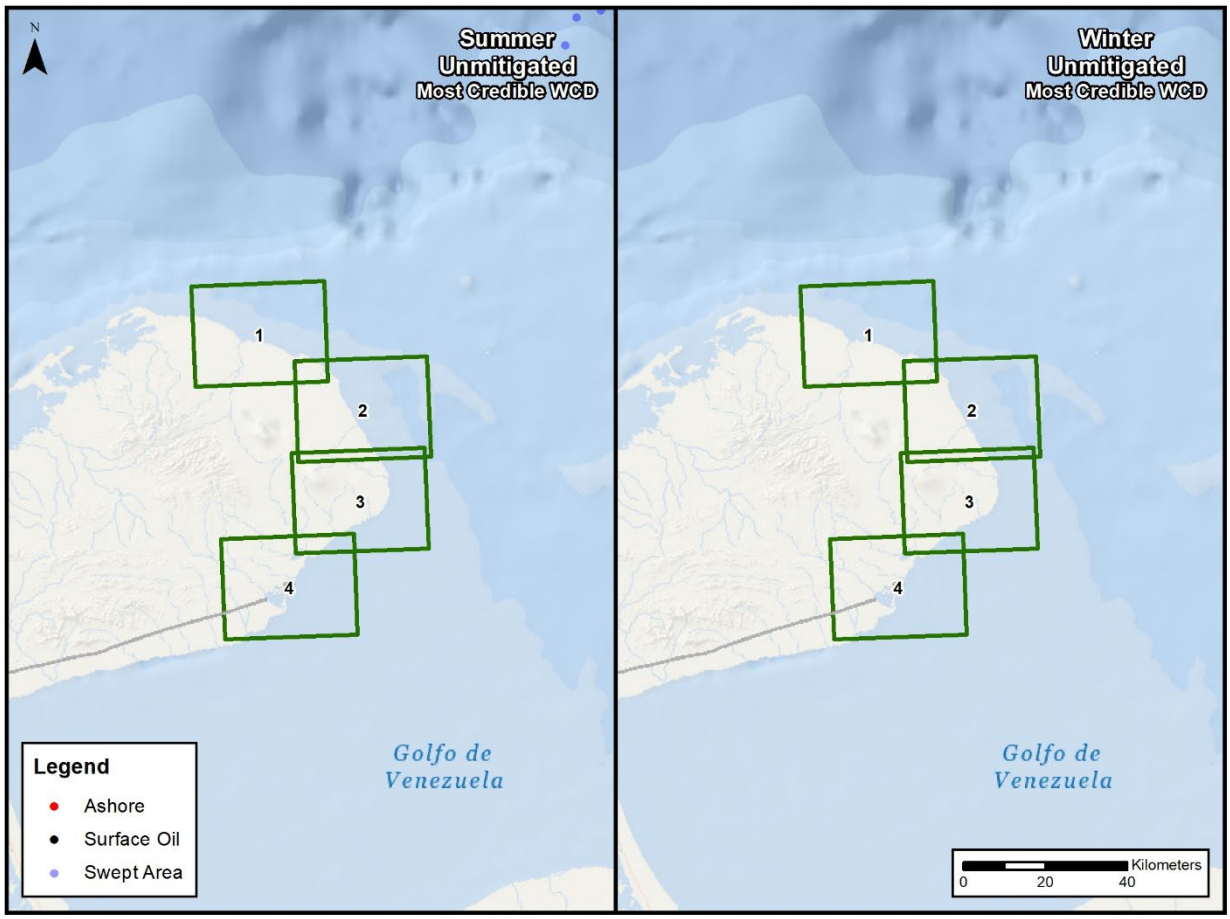


Figure 9.1-32a: Deterministic Map for Scenario 14—Predicted Transport after 45 Days from an Unmitigated 88,728 BPD (14,196 m^3) Subsea Release (Most Credible WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Colombia

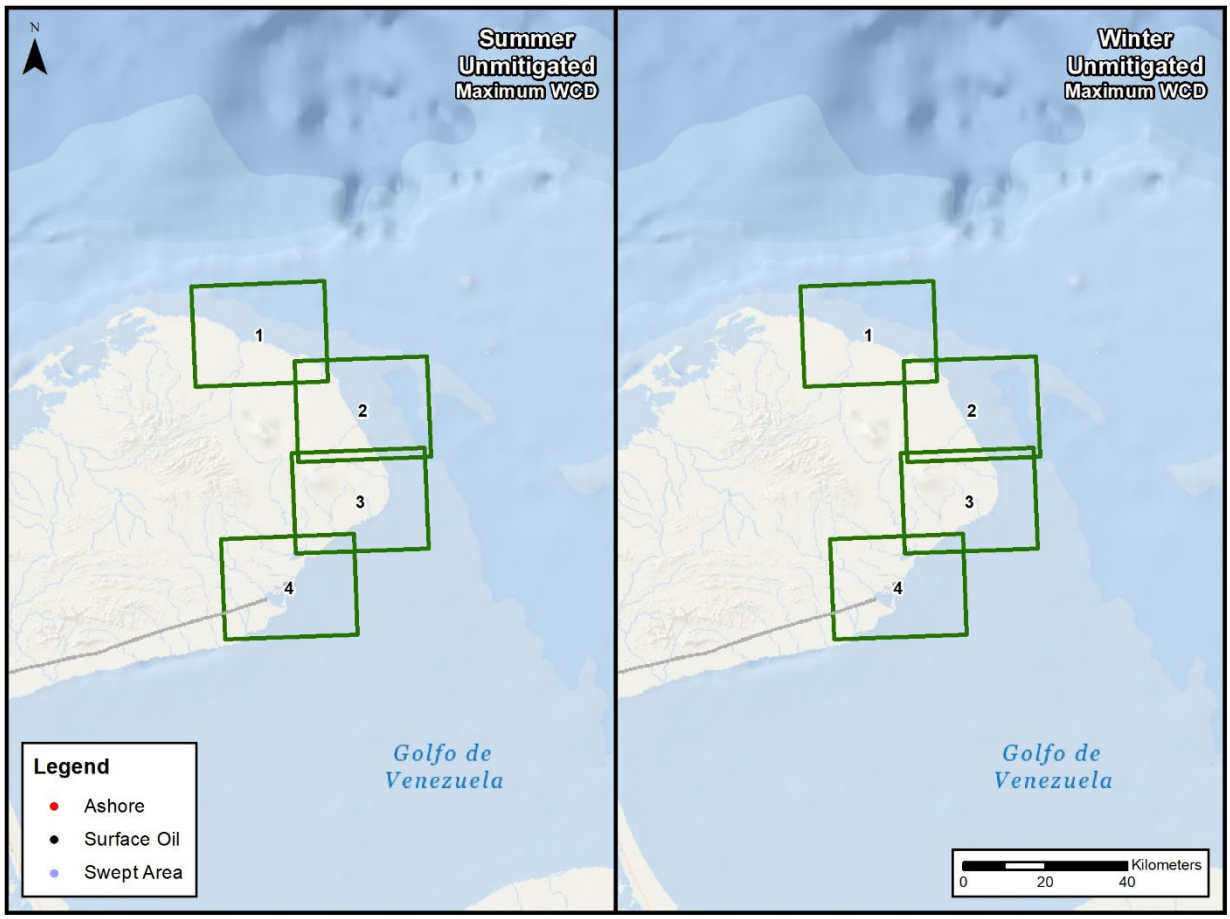


Figure 9.1-32b: Deterministic Map for Scenario 15—Predicted Transport after 45 Days from an Unmitigated 177,157 BPD (28,345 m^3) Subsea Release (Maximum WCD) of Crude Oil Lasting 30 Days, Showing Coastal Sensitivity Map Tiles for Colombia

9.1.7. Oil Spill Prevention, Control, and Emergency Response Measures

Regarding spill prevention controls associated with Scenarios 14 to 16 (loss-of-well-control release), EEPGL's well-control philosophy is focused on spill prevention using safety and risk management systems, management of change procedures, good international oilfield practice, and trained experienced personnel. EEPGL has a robust management system (Operations Integrity Management System [OIMS]; see Chapter 2, Description of the Project) that emphasizes attention to safety, well control, and environmental protection. Measures to avoid a loss of well control include:

- Proper preparation for wells (well design, well control equipment inspection and testing);
- Automatic detecting of any excess pressure entering the well during drilling;
- Use of physical barriers including automatic BOPs;
- Personnel training and proficiency drills for well control; and
- Use of drilling fluids to control pressures within the well.

Chapter 2 provides additional information related to well-control measures.

Regarding spill prevention controls associated with Scenario 13 (FPSO offloading spill), the measures to avoid a spill associated with FPSO offloading include:

- FPSO and tanker collision avoidance controls (as described in Section 9.1.1.3, Offshore Collision between FPSO and Offloading Tanker);
- Use of a certified engineered floating hose system;
- Floating hose damage protection controls;
- Use of emergency disconnect controls on the floating hose system;
- Use of load monitoring systems in the FPSO control room;
- Use of leak detection controls including infrared leak detection;
- Flood lighting for night operations; and
- Volumetric checks during offloading.

Section 2.14, Embedded Controls, provides additional information on spill prevention measures.

A representative list of spill prevention and mitigation measures and associated embedded controls for a typical FPSO development project (based on the Liza Phase 1 Development Project) can also be found in the OSRP.

In addition to the established spill prevention controls, EEPGL also has developed a detailed OSRP, which is included as part of the Project's ESMP, to ensure an effective response to an oil spill, if one were to occur. The OSRP builds on the coastal sensitivity mapping and oil spill modeling described herein and describes the response measures appropriate to the magnitude and complexity of a spill incident. The OSRP clearly delineates the responsibilities of each entity that would take part in a response and describes how EEPGL and its contractors would mobilize local oil spill response resources, which would be complemented by the regional and

international resources provided by its oil spill response contractors. The OSRP describes the EEPGL process for notifying the Government of Guyana with respect to mobilizing its resources. The lead agency for oil spill response in Guyana is the Civil Defense Commission, and the National Oil Spill Contingency Plan outlines how the Civil Defense Commission will coordinate the responses of other agencies, including MARAD (Government of Guyana 2020).

Due to the precautionary measures used by EEPGL to prevent and control an oil spill, as described above and in Chapter 2, the likelihood of a Tier II or III oil spill occurring is considered to be **Unlikely**.

9.1.8. Potential Effects on Wildlife and Pros and Cons of Dispersant Use

The decision regarding whether to use chemical dispersants for spill response is based on the characteristics of the spill, the biological and socioeconomic resources that are at risk from exposure to the oil, and the expected net impact of available response options. Protection of different resources is prioritized and the risk to each is established through a process of NEBA, also known as Spill Impact Mitigation Assessment, which considers the relative impacts and performance of different response options. The Guyana Oil Spill Contingency Plan includes use of dispersants as an oil spill response option.

Modern Type 3 dispersants that would be used in the unlikely event of a spill consist of a mixture of surfactants (such as those used in detergent products) and a solvent. Dispersant types can vary in formulation to target specific oil types, water salinities, and temperatures, but the mechanism by which the dispersants work is the same. The nature of dispersant use is such that in the event that more than one dispersant product is being used during a response, there will be some distance between application sites. For example, it is possible that two different products could be used for subsea dispersion and surface dispersion; however, the water depths in the PDA mean that these products are unlikely to mix. It is not considered feasible that synergistic toxicity would occur between different types of dispersants if they inadvertently came into contact with each other after application, as the mechanism of action and products are so similar for different Type 3 dispersants and the environmental concentrations are very low.

Dispersant use in general adds more chemicals to the environment; however, a wide range of scientific ecotoxicity studies, discussed below in more detail, have concluded that dispersed oil toxicity is not driven by the dispersant, but rather by the effect of the increased concentration of hydrocarbons in the water column, and is not due to the dispersant product itself. Additionally, it would be in only rare events (e.g., overspray) that exposure to dispersants alone would be expected to occur, as dispersant application is targeted to the oil surface rather than the water surface. It is common for dispersants to be sprayed at a rate of approximately 50 liters per hectare (5.3 gallons per acre; taking account of a typical oil slick thickness of 0.1 millimeter), providing a dispersant thickness of 0.005 millimeter that will immediately begin to rapidly dilute into the water column. Not accounting for horizontal dilution, this results in an initial dispersant concentration of 5 parts per million (ppm) when mixed into the top 1 meter (3.3 feet) and 0.5 ppm when mixed into the top 10 meters (32.8 feet) of the water column. The remainder of

this discussion therefore focuses on the combination of dispersant and oil as this is the form in which it would be present in the environment.

The reported toxicity of a range of dispersant products indicates that these products mostly fall into the IMO GESAMP (2014) rank of *slightly toxic* (>10 ppm) or *practically non-toxic* (100 to 1,000 ppm).

The key objectives of surface or subsea dispersant application are to reduce the volume of oil on the water surface and enhance natural biodegradation. When applied to spilled oil, dispersants reduce the surface tension between the water and oil, which allows the oil to become mixed into the water column as tiny droplets. The creation of these tiny droplets has been shown to significantly increase the biodegradation of oil. Rapid three-dimensional dilution of an oil spill in open ocean conditions will generally reduce concentrations of hydrocarbons in the water column to below acute toxicity thresholds such that toxic effects are unlikely (Lee et al. 2011). Furthermore, removing oil slicks from the water surface reduces risks to seabirds, marine mammals, and marine reptiles, which are most at risk from direct contact with surface slicks. Marine mammals and reptiles are also vulnerable to direct exposure to slicks as they surface to breathe, and they may also inhale high concentrations of hydrocarbon vapors from the air directly above a slick. It is generally accepted that the effective use of dispersants will significantly reduce the risk to birds, marine mammals, and marine reptiles.

Reducing the volume of surface oil also typically reduces the volume that strands on shorelines, where shorebirds, nesting turtles, or invertebrate species are vulnerable to direct contact or high concentrations of hydrocarbons. Oil on shorelines is also prone to much lower biodegradation rates and does not have the same potential for rapid toxicity reduction that can occur with open ocean dispersion.

The trade-off of dispersant use is that aqueous hydrocarbon concentrations are initially elevated as more of the oil is moved into the water column. As a result, species in the water column, including plankton and fish, are temporarily exposed to higher concentrations of hydrocarbons than would be present at depth under a floating slick. Water column hydrocarbon concentrations then reduce quickly over time and with distance from the treatment site as a result of dilution and biodegradation. Rapid three-dimensional dilution of the spill in open ocean conditions will generally reduce concentrations of hydrocarbons in the water column to levels where toxicity is unlikely (Lee et al. 2011).

Table 9.1-5 provides a summary of the potential benefits and risks associated with dispersant use on different environmental receptors. Further discussion on key receptors and effects is provided in the following sections. The assessment of impact severity in Table 9.1-5 considers the likelihood of injury to individual organisms, but also the extent to which populations are able to recover from impact (e.g., planktonic communities have rapid regeneration times, whereas mortality on species such as whales, marine turtles, and mangroves may result in longer-term population effects).

Table 9.1-5: Potential Severity to Marine Biota and Impact Mechanisms of Undispersed versus Dispersed Oil

Receptor	Potential Impact Severity and Key Mechanisms			
	Undispersed Oil		Dispersed Oil [a]	
Pelagic (Open Water)				
Marine Mammals	Medium/High	• Skin and eye irritation • Inhalation of hydrocarbons above slicks • Toxicity if bulk oil ingested	Low/Medium	• Some toxicity if oil ingested
Marine Reptiles	Medium/High	• Skin and eye irritation • Inhalation of hydrocarbons above slicks • Toxicity if bulk oil ingested	Low/Medium	• Some toxicity if oil ingested
Seabirds	High	• Fouling of feathers (hypothermia/drowning) • Skin and eye irritation • Toxicity if bulk oil ingested • Feeding interrupted by lack of visibility	Low	• Prey likely to avoid high concentrations of dispersed oil
Fish	Low	• Limited toxicity if fish are present near the surface where hydrocarbons are elevated beneath the slick • Fouling of gills if exposed to large oil droplets	Low/Medium	• Probable avoidance of high concentrations of dispersed oil • Depuration occurs in weeks to months
Plankton (including larval fish and invertebrate species)	Low	• Only impacted if present in surface waters	Medium	• Some toxicity if exposed to dispersed oil in water column
Commercial Fisheries	Medium to High	• Fouling of equipment and boats • Reduced value of stock or market restrictions due to fisheries closure or concerns of potential contamination	Medium to High	• Real or perceived contamination of fish results in reduced value or market restrictions due to fisheries closure
Benthic (Offshore)				
Invertebrates	Negligible	• Unlikely to be exposed	Low	• Dispersed oil in deep waters during subsea application
Benthic Fish	Negligible	• Unlikely to be exposed	Low	• Dispersed oil in deep waters during subsea application; active avoidance of high concentrations of dispersed oil

Receptor	Potential Impact Severity and Key Mechanisms			
	Undispersed Oil		Dispersed Oil [a]	
Shoreline/Intertidal				
Shorebirds	High	• Fouling of feathers (hypothermia/drowning) • Skin and eye irritation • Toxicity if bulk oil ingested • Feeding interrupted by lack of visibility	Low	• Some toxicity if oil ingested
Invertebrates	Medium	• Smothering of animals or habitat • Toxicity from external contact or ingestion of oil	Low	• Toxicity from dispersed oil ingestion
Marine Algae	Low/Medium	• Mortality • Temporary reduction in photosynthesis and growth	Low	• Temporary reduction in photosynthesis and growth
Intertidal Plants	Medium/High	• Temporary reduction in photosynthesis and growth • Mortality where heavy smothering	Low	• Some mortality • Temporary reduction in photosynthesis and growth

[a] Assumes dispersion has been effective and no surface slicks remain.

9.1.8.1. Marine Mammals and Marine Reptiles

Any animal that is directly contacted by hydrocarbons will be vulnerable to irritation of the external tissues, including skin and eyes, nasal, and other body cavities (AMSA 2013). This type of impact is relevant to marine mammals and marine turtles that may swim through the slick (Fingas 2011; St. Aubin and Lounsbury 1990).

Hydrocarbons may be ingested coincidentally with food, or may be inhaled from the air directly above a slick by animals such as marine turtles and marine mammals (Rainer Engelhardt 1983; Fingas 2011; St. Aubin and Lounsbury 1990).

Where shoreline oiling occurs, marine turtles and their hatchlings are vulnerable to direct exposure, leading to potential smothering and possible toxic effects.

There are no reports in the literature of experimental exposure of marine mammals or reptiles to chemically dispersed hydrocarbons, likely due to a combination of the practical and ethical challenges associated with subjecting captive marine mammals to potentially harmful biological testing. Dead dolphins and marine turtles were found during the Macondo spill, in which large amounts of dispersant was applied to the spill. It therefore cannot be discounted that impacts on these animals were related to their exposure to chemically dispersed oil, although there were also extensive surface slicks to which animals were likely exposed and which could be responsible for the observed impacts. However, dispersion of oil will generally reduce risk to marine mammals and marine reptiles by preventing their direct contact with untreated oil or inhalation of high concentrations of hydrocarbon vapors. Both groups have the capacity to process toxins internally and depurate harmful chemicals. The rapid dilution of dispersed oil means that typically only low levels of exposure to toxic compounds would occur.

While there are few reported cases of mortality of marine mammals or reptiles during any documented oil spills, it is generally accepted that effective dispersion will reduce the risk of injury to these species, particularly where dispersion reduces exposure of wildlife to surface slicks and stranded oil.

9.1.8.2. Birds

Direct contact with undispersed oil may cause irritation of sensitive tissues, such as eyes, skin, and internal cavities (Fingas 2011; St. Aubin and Lounsbury 1990; AMSA 2013).

Hydrocarbons may be ingested coincidentally with food or during preening (Rainer Engelhardt 1983; Fingas 2011; St. Aubin and Lounsbury 1990).

Eggshells are known to be permeable to hydrocarbons that may be transferred from parents or through direct contact such as when an oiled bird returns to the nest from feeding (Finch et al. 2012; Peakall et al. 1987).

The greatest risk to birds from an oil spill is reported to be where their feathers become fouled by oil, subsequently damaging the feather structure, interfering with or inhibiting flying and waterproofing, and rendering the birds vulnerable to hypothermia and drowning. If present in the area, large numbers of seabirds may be impacted or killed where there is heavy surface oiling. They may also avoid or limit hunting in areas where surface slicks limit the visibility of prey; however, such avoidance may reduce more serious harm than if the bird were to dive through the surface slick.

Effective dispersion of oil will reduce the area of surface slicks and shoreline oiling, avoiding the most significant impacts on birds that result from direct contact with the oil. There is also evidence that dispersed oil is less toxic to developing embryos (where oil is transferred from the parent bird to an egg) than undispersed oil (Albers 1979, cited in Eastin and Rattner 1982).

The use of dispersant will reduce the potential impacts on seabirds and shorebirds relative to potential impacts from an untreated oil spill.

9.1.8.3. Fish and Commercial Fisheries

Toxicity in adult fish has been reported in response to crude oils, heavy fuel oil, and diesel (Holdway 2002; Shigenaka 2011). Fish will generally only be exposed to harmful concentrations of oil from an undispersed slick where they are present in shallow waters beneath a slick or in a location of high concentrations of entrained oil from a subsurface release.

While fish are known to take up hydrocarbons in their tissues, the majority of studies, either from laboratory trials or of fish collected after spill events (including the Hebei Spirit, Macondo, and Sea Empress spills) exhibit evidence of fish tissues returning to normal levels within 2 months of exposure (Challenger and Mauseth 2011; Davis et al. 2002; Gagnon and Rawson 2011; Gohlke et al. 2011; Jung et al. 2011; Law et al. 1997; Rawson et al. 2011).

The use of dispersant will result in a higher concentration of hydrocarbons in the water column, where fish species may be exposed. The degree of exposure will depend on the water depth and the proximity of the animals to the dispersant application and length of time they remain in the area of the spill. Studies comparing chemically dispersed hydrocarbon mixtures, including crude oil and Corexit 9500, to mechanically dispersed oil on fish species have found similar results (Hemmer et al. 2011; Wetzel and Van Fleet 2001). The National Academy of Sciences published a workshop consensus describing exposure concentration thresholds of concern (toxicological-relevant concentrations) for dispersed oil on adult fish of 0.5 ppm for a 96-hour exposure, increasing to 100 ppm over 0 to 3 hours (high concern) and 10 ppm over 0 to 3 hours (low concern) (NRC 2005). Rapid dilution of dispersed oil at sea is expected to reduce water column exposure below these thresholds within minutes to hours.

Predatory fish may be exposed to, and accumulate, hydrocarbons from prey species. However, the concentrations of hydrocarbon to which they would be exposed through this route would be small unless very large amounts of contaminated prey were consumed, although short-term elevated hydrocarbons or biomarkers of contamination may be present in the tissues of predatory species exposed in this way.

Fish are at greater risk from dispersed oil than undispersed surface slicks; however, effects from dispersed oil will be limited in area due to high rates of dilution that would rapidly reduce concentrations below harmful levels.

A marine oil spill will typically result in concern regarding contamination of fish stocks. This can result in fisheries closures while fish are assessed for safety, and can affect market value of fish. Additionally, surface oil slicks can foul fishing vessels and equipment. As noted above, there is a slightly higher potential for fish exposure to hydrocarbons in the water column where dispersants are used, but overall impacts on a fishery are not likely to be greater or of longer duration as a result of dispersant use.

9.1.8.4. Benthic Species

Except in shallow waters and intertidal areas where significant hydrocarbon concentrations may occur, surface slicks pose very limited risks to benthic species. Dispersants may somewhat facilitate the likelihood of contamination of sediments by increasing the concentration of hydrocarbons deeper in the water column, although dispersants do not cause oil to sink. However, in deep water, the concentrations that would become entrained in sediments are likely to be very low. Conversely, the reduced viscosity of the hydrocarbon as a result of chemical dispersion may also reduce the subsequent tendency for the product to persist in sediments.

The majority of benthic invertebrates reproduce rapidly and many have broadcast spawning modes of reproduction. As a consequence, localized impacts are unlikely to result in significant population level impacts. The potential risks to benthic species are generally cited as the basis for avoiding dispersant application in shallow or confined waters; however, dispersant use in deep waters with good mixing is considered unlikely to result in additional harm to benthic species relative to undispersed oil.

9.1.8.5. Plankton

Like fish, the exposure of planktonic species (including phytoplankton, zooplankton, and larval invertebrates and fish) to undispersed oil will be determined by their proximity to the water surface. Where plankton exhibiting diurnal cycles rise to the surface, they are vulnerable to becoming entrained in surface oil and mortality would inevitably result.

Where oil has been dispersed, elevated concentrations of particulate and dissolved hydrocarbons in the water column may produce a toxic effect to planktonic species, which are considered to be highly sensitive to oil contamination. However, impacts are expected to be localized based on dilution of the dispersed oil, and plankton are abundant and typically have rapid reproductive times.

Dispersed oil is expected to pose a greater threat to planktonic species than undispersed oil due to the higher concentration of oil present in the water column. Other than where protection of large numbers of fish or invertebrate larvae is a priority, impacts on plankton alone would generally not be considered a barrier to dispersant use, particularly if use reduces impacts on more vulnerable environmental or socioeconomic resources.

9.1.8.6. Marine Algae and Marine Plants

Marine algae and marine plants are considered to not be particularly susceptible to impacts from untreated hydrocarbons. Studies of actual spills found no significant differences between oiled and unoiled seagrass meadows following large spills of crude oil (Kenworthy et al. 1993), or of heavy fuel oil contaminated by lighter fuel products (Taylor and Rasheed 2011). Short-term laboratory exposure (up to 10 hours) of seagrasses to various oils likewise did not have a significant impact, although longer exposures did result in reduced growth rates and/or photosynthetic activity for some species (Thorhaug and Marcus 1987; Wilson and Ralph 2012). Mortality of intertidal seagrasses have occurred at a site heavily oiled with medium weight crude in Galeta, in which oil became trapped in mangroves and sediments and continued releases occurred over an extended period of many years (Burns et al. 1994).

Smothering of macroalgae may occur if it is exposed on the falling tide; however, the slick would generally be lifted off by the returning tide, particularly in the case of light oils, reducing the period of exposure. Studies identified no significant impacts on algal communities following the *Hebei Spirit* spill of heavy fuel oil (Edgar and Barrett 2000), the *Prestige* crude oil spill (Lobón et al. 2008), or the *World Prodigy* spill of marine diesel (Peckol et al. 1990).

Dispersed oils have been shown to impact growth rates of seagrasses and have increased toxicity to algae compared to those where untreated surface slicks were floating above the plants (Thorhaug and Marcus 1987; Wilson and Ralph 2012). Concentrations in these experiments were typically very high, representative of dispersant application to an oil slick in shallow water.

Except in shallow, confined waters, there is not expected to be any significant benefit to marine algae or plants from either leaving a slick undispersed or dispersing the slick.

9.1.8.7. Intertidal Plants

Hydrocarbons can impact terrestrial plants as a result of smothering of parts of the plant (e.g., mangroves) used for gas exchange or by the loss of leaves due to chemical burning in the less likely event of direct contact of the leaves with the slick (Duke et al. 1999). It is also known that mangroves take up hydrocarbons from contact with leaves, roots, or sediments, and it is suspected that this uptake has the potential to cause defoliation through leaf damage and tree death (Wardrop 1987).

Intertidal sediments can retain hydrocarbons and act as long-term reservoirs, where continued releases and fresh slicks can occur for up to 5 years after the initial spill. These sediments can still contain elevated levels of hydrocarbons up to 20 years after a crude oil or diesel spill (Corredor et al. 1990; Teal et al. 1992). This can result in long-term impacts on vegetation, including mangroves and saltmarsh species (Getter et al. 1985; Ward et al. 2003; Sadaba and Barnuevo 2011; DeMicco et al. 2011).

Results from a 25-year study examining the effects of dispersed crude oil versus non-dispersed crude oil on tropical marine ecosystems in Panama indicate that dispersants prevent long-term contamination to mangrove forests and provided the conditions for ecosystem and habitat recovery, as opposed to the site where untreated oil led to chronic exposure to aromatic hydrocarbons and continued to inhibit recovery and repopulation (DeMicco et al. 2011). Experimental field exposures also found that fresh, dispersed crude had significantly less impact on mangroves than untreated oil (Ballou et al. 1989).

Effective dispersion of heavy oil prior to it reaching intertidal areas is also likely to reduce impacts related to smothering of vegetation.

9.1.9. Claims and Livelihood Remediation Processes

In the unlikely event of an oil spill causing losses to stakeholders, EEPGL would establish a claims process and, depending on the magnitude of the oil spill, a livelihood remediation program. The purpose of the claims process would be to provide compensation as appropriate for asset losses and the purpose of a livelihood remediation program would be to restore the welfare and livelihoods of affected persons to conditions no less than pre-impact conditions. Both processes would be transparent, fair, and conducted in a timely manner. EEPGL, in consultation with the Government of Guyana and other jurisdictions (as required), would establish the designated geographic zones associated with the claims and, as applicable, livelihood remediation processes; these would be commensurate with the magnitude of the impacts of the spill. Eligible persons would be compensated as appropriate based on the magnitude of Project-related impacts they individually experienced, either in regard to human health or as a result of economic loss.

It is anticipated that EEPGL would establish steering committees, working groups, and stakeholder engagement-specific entities to determine eligible stakeholders, standard entitlements, and eligibility criteria for further livelihood compensation and assistance. EEPGL would consider establishing an independent implementation entity as soon as reasonably practicable after the spill, to assist in the process of livelihood remediation planning while the initial compensation efforts are ongoing. Depending on the extent of losses, livelihood remediation efforts may potentially range from early support initiatives (within the first year), to transition support (typically from 1 to 2 years after impact), to longer-term support, as defined by the duration of spill impacts.

9.1.10. Vessel Collision with a Third-Party Vessel, Structure, or Animal (Non-Spill Related Impacts)

9.1.10.1. Vessel Collision with a Third-Party Vessel or Structure

Section 9.1.1.4, Nearshore Collision between a Project Supply Vessel and a Third-Party Vessel or Structure, or Grounding, and Section 9.1.1.6, Offshore Collision between Project Vessels or between a Project Vessel and another Third-Party Vessel, describe potential scenarios in which a Project vessel collision could occur with a third-party vessel or structure, resulting in a spill of hydrocarbons. This section addresses the potential for such a collision, but focuses on the

potential non-spill related aspects. This section also addresses the potential for a Project vessel to collide with a marine animal, specifically focusing on marine mammals, marine turtles, and riverine mammals.

As discussed in Section 9.1.1.4, a variety of Project vessels will supply and support drilling, installation, production operations, and decommissioning activities, and these vessels will transit between the Guyana shorebases and the PDA. There is a potential for collisions between these vessels and third-party vessels/structures in the Georgetown Harbour / Demerara River area or for the nearshore grounding of a vessel. Such an incident may result from navigation error or a temporary loss of power that affects the ability of a vessel to steer. Damage to an impacted structure may require repairs, and in extreme cases, temporary closure of the structure; this has occurred before in Guyana (e.g., damage to and temporary closure of the Demerara Harbour Bridge). In the case of the Project, however, the Georgetown shorebases are downstream of the Demerara Harbour Bridge, which reduces the probability of a Project-related vessel colliding with this structure.

Section 9.1.1.4 includes a summary of the embedded controls that will be in place to reduce the potential for a nearshore collision to occur. Based on consideration of these controls, the likelihood of Project vessel accidents causing any significant damage to third party vessels or structures, or causing significant injury, is considered **Unlikely**.

Section 9.1.1.6 includes a summary of the embedded controls that will be in place and the additional mitigation measures that will be employed to reduce the potential for an offshore collision to occur. Based on these controls and measures, the potential for an offshore collision between a Project vessel and a third party vessel is also considered **Unlikely**.

9.1.10.2. Vessel Collision with a Marine Mammal

Collisions with vessels can injure or kill marine mammals. An incident like this is extremely rare for slower-moving vessels. Marine mammals possess acute senses of hearing that they can use to detect approaching vessels, and they have the necessary swimming speed capability to avoid collisions. Unless large whales are extremely distracted by feeding or breeding (neither activity is expected in these waters) the animals are aware of the vessels and fast enough to move out of the way. Nevertheless, marine mammals are inherently vulnerable to ship strikes when they surface to breathe or to feed. This vulnerability increases in shallow, nearshore areas, where opportunities to maneuver are reduced. Most Project activities will take place in deep ocean waters, and vessel speeds within the PDA will be low, reducing the potential for collisions. The only planned nearshore activities will be supply vessels entering or exiting shorebases, but even at the peak of drilling and installation, the incremental increase in traffic near shorebases will represent a small increase in overall risk to marine mammals. There is very little potential for collisions to occur within the PDA, but the potential remains for individual dolphins or whales to collide with vessels transiting between the PDA and shorebases. The greatest potential for collisions to occur will be during drilling and installation, when vessel traffic is at its peak; accordingly, the risk of injury or mortality from vessel collisions will be higher during drilling and installation than during other stages of the Project.

In the unlikely event of a collision, the severity of injuries typically depends on the size and speed of the vessel; the probability a collision will kill the animal increases about 8 times as speed increases from 7 to 18 knots (13 to 33 kilometers per hour) (Knowlton and Kraus 2001; Laist et al. 2001; Vanderlaan and Taggart 2007; De Stephanis and Urquiola 2006). There are no reported incidents of collisions with whales by industry vessels (excluding tankers moving at high speeds) when mitigations are in place to slow for observed whales.

With respect to the potential for injury and mortality from vessels strikes, EEPGL will use the following embedded controls for the Project (see Section 2.14, Embedded Controls):

- Provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals at the sea surface.
- Provide standing instruction to Project-dedicated vessel masters to reduce their speed within 300 meters (984 feet) of observed marine mammals, and to not approach the animals closer than 100 meters (328 feet), when possible, to reduce probability of collisions. EEPGL-contracted vessels are trained and instructed to slow when they observe a marine mammal, riverine mammal, marine turtle, or any floating debris or objects—as well as other vessels—and take corrective actions to alter course to avoid such. Such vessels reduce their speed to 5 knots (9.3 kilometers per hour) when entering the Demerara River awaiting berth space to dock. Vessels also slow to less than 5 knots and are prohibited from entering the 2-nautical-mile (3.7-kilometer) exclusion zone around the FPSO when offloading and the 500-meter (1,640-foot) exclusion zone around drill ships and FPSO during all other times.

Although the embedded controls noted above are expected to greatly reduce the possibility of a Project vessel striking a marine mammal, it is conservatively assumed that over the duration of the Project life cycle (at least 20 years), such an event is **Possible**.

9.1.10.3. Vessel Collision with a Marine Turtle

Collisions with vessels can also injure or kill marine turtles. Marine turtles tend to spend most of their time at sea at or near the sea surface as verified by the dive profile data described in Section 7.7.2, Existing Conditions—Marine Turtles, and do not possess the acute sense of hearing or the swimming speed that cetaceans use to avoid collisions. Marine turtles are inherently more vulnerable to ship strikes in the shallow nearshore areas, where they congregate prior to coming ashore to nest, than they are in the open ocean. This increased vulnerability is caused by the higher concentrations of turtles in the shallow nearshore areas. Most Project activities will take place in deep ocean waters, and vessel speeds within the PDA will be low, further reducing the potential for collisions. The only planned nearshore activities will be supply vessels entering/exiting shorebases; the anticipated options for shorebases are all located more than 100 kilometers (62 miles) away from the nearest portion of the Shell Beach Protected Area (SBPA), where most marine-turtle nesting in Guyana occurs (and where turtles may aggregate pre- and post-nesting as suggested by tagging data).

There is very little potential for collisions to occur within the PDA, but the potential remains for individual turtles to collide with vessels transiting between the PDA and shorebases. The potential for the greatest number of collisions to occur will be during drilling and installation, when vessel traffic is at its peak, so the risk of injury or mortality from vessel collisions will be slightly higher during drilling and installation than during other stages of the Project.

Hazel et al. (2007) investigated the influence of vessel speed on the probability of vessel strikes of large marine turtles. Avoidance ability is a combination of swimming speed and time from alert to approach. Loggerheads and other very large turtles can swim as fast as 24 kilometers per hour (13 knots). Therefore, they have the ability to avoid slower-moving vessels. The study showed (using a small recreational vessel) that the majority of turtles reacted in time to avoid slower vessels. Since larger vessels are also louder, the animals are able to sense their approach from even greater distances. Wirsing et al. (2008) studied the speed and maneuverability of adult loggerhead turtles to measure their speed and avoidance behavior. Both studies are consistent with adult turtles being aware and agile enough to easily avoid slower-moving vessels (less than 15 knots [27.8 kilometers per hour]). An incident of a slow-moving vessel colliding with a marine turtle is thus extremely rare, particularly in the open ocean. As discussed in Sections 7.5, Marine Mammals, and 7.7, Marine Turtles, marine turtles are very rarely if ever observed 200+ kilometers (124+ miles) offshore in the Stabroek Block. Of the more that 1,300 protected species detections recorded by EEPGL since Protected Species Observer (PSO) observations began in 2015, only 17 were marine turtles. The Turtle Telemetry Tracking Report provided in Appendix Q, Final Analysis Report—2018–2020 Shell Beach Turtle Tracking Project (Volume II of the regulatory submittal) further supports that marine turtles transiting along the Guyana Coast preparing to nest or re-nest will normally transit much closer to shore.

With respect to the potential for injury or mortality from vessel strikes, EEPGL will use the following embedded control for the Project (see Section 2.14, Embedded Controls):

- Provide standing instruction to Project-dedicated vessel masters to avoid marine turtles while underway, to reduce their speed within 300 meters (984 feet) of observed marine turtles (noting that such observations are inherently difficult), and to not approach the animals closer than 100 meters (328 feet), when possible, to reduce probability of collisions. EEPGL-contracted vessels are trained and instructed to slow when they observe a marine mammal, riverine mammal, marine turtle, or any floating debris or objects—as well as other vessels—and take corrective actions to alter course to avoid such. Such vessels reduce their speed to 5 knots (9.3 kilometers per hour) when entering the Demerara River awaiting berth space to dock. Vessels also slow to less than 5 knots and are prohibited from entering the 2-nautical-mile (3.7-kilometer) exclusion zone around the FPSO when offloading and the 500-meter (1,640-foot) exclusion zone around drill ships and FPSO during all other times.

The embedded control noted above is expected to greatly reduce the possibility of a Project vessel striking a marine turtle; accordingly, it is considered that such an event is **Unlikely**.

9.1.10.4. Vessel Collision with a Riverine Mammal

Collisions with vessels can injure or kill riverine mammals. As described in Section 7.6.3, Impact Assessment—Riverine Mammals, the American manatee (*Trichechus manatus*) and the neotropical otter (*Lontra longicaudis*) are the most likely riverine mammals to occur within areas affected by planned Project activities, and these species do not possess the acute sense of hearing or the swimming speed and agility that marine mammals rely on to avoid collisions. Like marine turtles, these species tend to spend most of their time near the water's surface.

Most Project activities will take place in deep ocean waters, and the only portion of the Direct AOI where riverine mammals are likely to occur is the Demerara River. The only planned Project activities in the Demerara River will be supply vessels entering/exiting shorebases. Vessel speeds within the river will be low, reducing the potential for collisions. The likelihood of a collision is low due to these factors, but these factors notwithstanding, the potential remains for individual riverine mammals to collide with vessels transiting Georgetown Harbour and the Demerara River. The potential for the greatest number of collisions to occur will be during drilling and installation, when vessel traffic is at its peak, so the risk of injury or mortality from vessel collisions will be slightly higher during drilling and installation than during other stages of the Project.

The probability of a collision between a riverine mammal (including manatees) and a vessel is primarily controlled by speed. Slow speeds (approximately 5 knots [9.3 kilometers per hour]) within rivers drastically reduce the possibility of collision with manatees. Laist et al. (2006) reported that in Florida, speed restrictions (approximately 5 knots) are effective in significantly reducing collisions with manatees. Calleson and Frohlich (2007) documented that reducing boat speed allows the vessel and the manatee more time to detect the other and react accordingly to avoid a collision. Rycyk et al. (2018) documented tagged manatee behavior during boat approaches in Florida and concluded that faster boats pose a greater risk of collision with manatees than do slower boats. Compared to fast approaches, slower passes allow the manatee more time to respond, and behavioral changes occur earlier relative to the time of the boat's closest approach.

With respect to the potential for injury or mortality from vessels strikes, EEPGL will use the following embedded controls for the Project (see Section 2.14, Embedded Controls):

- Provide awareness training to Project-dedicated marine personnel to recognize signs of riverine mammals at the sea surface.
- Provide standing instruction to Project-dedicated vessel masters to avoid riverine mammals, while underway and reduce speed or deviate from course, when possible, to reduce probability of collisions. EEPGL-contracted vessels are trained and instructed to slow when they observe a marine mammal, riverine mammal, marine turtle, or any floating debris or objects—as well as other vessels—and take corrective actions to alter course to avoid such. Such vessels reduce their speed to 5 knots (9.3 kilometers per hour) when entering the Demerara River awaiting berth space to dock.

The embedded control noted above is expected to greatly reduce the possibility of a Project vessel striking a riverine mammal; accordingly, it is considered that such an event is **Unlikely**.

9.1.11. Discharge of Untreated Wastewater from the FPSO

The FPSO will be equipped with onboard water treating systems, one of which will treat black water (waste from toilets or urinals) prior to discharge overboard. The FPSO also has a large storage tank with capacity to store up to 7 days of sewage in the event of an upset to the treatment system. In addition, multiple closed valves prevent accidental release of black water to the ocean. In the unlikely event it is determined that the sewage treatment system is not operating properly and wastewater is temporarily discharged outside of specification limits, the black water stream will be redirected to the above-referenced storage tank. If the treatment system cannot be repaired within 7 days, alternative means of managing black water will be implemented. The primary alternative in this case would be to offload the black water from the storage tank to a supply vessel—for subsequent treatment onshore. The secondary alternative in this case would be to transfer the black water to the oily bilge tank, in which case the contents of the bilge water would be offloaded to a supply vessel—for subsequent treatment onshore. In the event that black water storage tank and oily bilge tank capacity are not available and a supply vessel is not available to take on the re-directed black water stream, the FPSO is configured to have the ability to pump the black water stream overboard. In summary, the potential for a discharge of untreated black water to occur is considered **Unlikely** for the following reasons:

- The black water treatment system will be subjected to routine inspection and maintenance, providing the opportunity to identify and correct issues requiring attention prior to an upset scenario occurring.
- The black water treatment system will be designed to include capacity for storage of 7 days of untreated wastewater in the black water holding tank in the event of an upset to the treatment system, and for additional storage in the oily bilge tank. Additionally, the FPSO will be configured to allow for the black water stream to be redirected to the IMO flange, where it can be offloaded directly to a supply vessel, for subsequent treatment on shore. These measures afford time to avoid overboard discharge for a period of time while corrective actions on the treatment system can be implemented, without impacting the ability of the FPSO to continue operating.
- Multiple closed valves prevent accidental release of black water to the ocean.

Although such a release is **Unlikely**, computational modeling was conducted for an equipment failure scenario where there is an upset in the black water treatment system. Under this equipment failure scenario, it was assumed that untreated black water from accommodations and the clinic would bypass the macerator and the sewage-holding tank and be discharged directly overboard through an emergency outfall. Modeling was performed to assess the plume that would result from this scenario. Based on an average sewage generation rate per person and a capacity of 180 persons on board for the FPSO, incorporating a 10 percent contingency factor on the design discharge rate of 85 BPD (13.6 m^3), and using conservative estimates of

wastewater characteristics (coliform: 10,000,000 colony forming units per 100 milliliters; 5-day biochemical oxygen demand [BOD_5]: 350 milligrams per liter [mg/L]; and total suspended solids [TSS]: 650 mg/L), the modeling results show that the temporary release of untreated wastewater will result in a plume of limited extent. The maximum predicted BOD_5, TSS, and coliform concentrations never exceed the end-of-pipe levels recommended by the IMO's 2012 *Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants* (IMO 2012). Additional detail regarding the modeling of this scenario is provided in Appendix C, Water Quality Modeling Report.

9.1.12. FPSO or Drill Ship Fire

Although an **Unlikely** event, a number of potential scenarios could lead to a fire event on the FPSO or a drill ship (e.g., inadvertent ignition of oily rags or related materials, electrical panel fault, etc.). To reduce the possibility and consequence of a fire, EEPGL or the drill ship operator will implement a series of fire prevention controls (design-based and operations) in alignment with good international oilfield practice. Multiple automated safety features are designed into the FPSO and drill ships to minimize the risk of any fire (e.g., fire detection, automated shut-off valves, alarms, deluge system, fire protection) as well as trained operations and maintenance crew. Additionally, the FPSO and drill ships will have a robust emergency response plan to direct activities in the event of such a fire. Any fire would likely be quickly detected and extinguished, via either an automated and/or manual system. Further escalation of a fire event would be a rare event.

The firewater used in a response would likely be captured within the deck open-drain system, but some could potentially wash over the deck to the sea. While these measures would significantly reduce the potential for a fire to occur in the first place, operational procedures and engineering design systems would further limit the potential for a release of hydrocarbon-containing firewater overboard during response. The possible washover of firewater from the FPSO or drill ship deck to the sea could result in the discharge of relatively minor amounts of hydrocarbons, with the potential for related localized environmental impacts.

9.1.13. Onshore Vehicular Accident

Based on a traffic study conducted in 2021, the results of which are presented as Appendix T, Traffic Impact Assessment, the Project will result in a minimal increase in onshore vehicular traffic around the existing shorebases that will be used by the Project. The Georgetown shorebase operations have been designed to minimize road movement of freight. An additional traffic study was conducted in 2019 for key intersections in the greater Georgetown area, and this study also indicated the Project will result in minimal impact on vehicular traffic at these intersections (see Appendix T).

Although the addition of Project-related traffic is expected to be incrementally insignificant with respect to existing traffic conditions in the vicinity of the shorebases and at the other key Georgetown area intersections evaluated, the potential for a vehicular accident involving a Project-related vehicle is considered **Possible**.

9.1.14. Collisions between Project Vessels/Helicopters and Seabirds

While individual seabirds could be significantly impacted through contact with the FPSO flare structure, its flame, or its radiant heat plume, the likelihood of a seabird being present in the heat zone when temporary, non-routine flaring is occurring is extremely low. Accordingly, this unplanned event is focused on direct mortality and injury related to vessel or helicopter strikes.

Rafting seabirds may suffer injury or mortality from collision with vessels transiting to and from the FPSO. However, rafters are not likely to be present in large aggregations in the PDA because of the metocean conditions offshore Guyana—namely a strong surface current, which is likely to make the surface waters unsuitable for the large aggregations of species that favor more calm and sheltered conditions. The EEPGL seismic surveys conducted in the Stabroek Block from 2015 through 2021 have not document any concentrations of rafting seabirds in the area during their survey periods. On the rare occasions that suitable conditions for rafting occur in the PDA and seabirds are present in high enough concentrations to form rafts, individual seabirds could be susceptible to vessel strike and related injury or mortality. However, large seabird rafts are easily detectible by oncoming vessels, and these vessels could maneuver to avoid them if the birds do not move out of the vessels' path.

Helicopters will be used as a form of transit to/from the Guyana shorebases and offshore vessels, and could adversely impact seabirds through helicopter strike of individuals flying near helicopters transiting around or in route to/from the drill ships, FPSO, and installation vessels. Helicopter trips to and from the PDA are not expected to exceed more than a few each day, so the potential for helicopter-bird interactions is expected to be low.

With respect to the potential for marine vessels colliding with rafting seabirds, EEPGL will use the following embedded control for the Project (see Section 2.14, Embedded Controls):

- Provide standing instruction to Project-dedicated vessel masters to avoid any identified rafting seabirds when transiting to and from PDA.

The embedded control noted above is expected to greatly reduce the possibility of a Project vessel striking rafting seabirds (that do not move out of the vessel's path on their own).

Given the low likelihood of vessels encountering rafting seabirds and the above embedded control, as well as the limited number of helicopter flights per day between the PDA and shore, the likelihood of a vessel or helicopter interaction with a seabird is considered **Unlikely**.

9.1.15. Seabird Collision with FPSO Flare Tower, Flame, or Radiant Heat Plume

A reasonable worst-case estimate for non-routine flaring emissions, while not an explicit part of the Project design, has been analyzed and is presented in Section 6.1, Air Quality, Climate, and Climate Change. The FPSO will have a flare system for the collection and safe disposition of produced hydrocarbon gases resulting from unplanned, non-routine maintenance or repairs, or emergency shutdown events. Should flaring occur, the flame and radiant heat plume will emanate from a flare tower located on top of the FPSO. While individual seabirds could be

significantly impacted through contact with the FPSO flare tower, its flame, or its radiant heat plume, the likelihood of a seabird colliding with the tower or being present in the heat zone when temporary, non-routine flaring is occurring is extremely low. To date, large flocks of birds have been documented very rarely by PSOs or by marine bird surveyors in the Stabroek Block (Appendix K, Marine Bird Study Report: Marine Bird Survey 2017–2020). While this does not preclude the possibility of a flock to occur, it is considered relatively rare and any such flocks would likely be small. Even during migration, most individuals are solitary or flying in loose groups (spread out spatially). Accordingly, in the circumstance that such an event occurred, it would likely only impact a single individual. However, it is conservatively assumed that over the duration of the Project life cycle (at least 20 years) such an event is **Possible**.

9.1.16. Summary of Unplanned Events Interactions with Resources/Receptors

Table 9.1-6 indicates which resources/receptors would potentially be impacted by a NADF release (Scenario 16), coastal fuel spill (represented by Scenario 3), and marine oil spill (represented by Scenarios 13 through 15), vessel collisions (non-spill related impacts), a discharge of untreated wastewater from the FPSO, or vehicular accidents. While several other coastal and marine oil spill scenarios are described above, the higher-volume marine oil spill and coastal fuel spill scenarios were the focus of the resource-specific assessments, so as to provide a conservative assessment of potential risk. The remainder of this chapter evaluates the risk of each of these potential impacts, considering the likelihood of the event and the potential consequence of the event with respect to resultant impacts on the relevant resources/receptors. For simplicity, although NADF is technically a “hydrocarbon” and not an “oil,” releases of both NADF and oil are generically referred to as “oil spills” in the remainder of this section.

Table 9.1-6: Resources/Receptors Potentially Impacted by Unplanned Events

Resource/Receptor	Oil Spill		Coastal Fuel Spill	Vessel Collision [a]	Discharge of Untreated Wastewater from the FPSO	Vehicular Accident	Collision between Seabird and Project Vessel or Helicopter	Seabird Collision with FPSO Flare Tower, Flame, or Radiant Heat Plume
	Marine	NADF						
Physical Resources								
Air Quality and Climate	X		X					
Sound (Airborne)								
Marine Geology and Sediments	X	X	X					
Marine Water Quality	X	X	X		X			
Biological Resources/Receptors								
Protected Areas	X							
Special Status Species—Fish	X		X		X			
Special Status Species—Birds	X		X		X		X	X
Coastal Habitats	X		X					
Coastal Wildlife	X		X					
Seabirds	X				X		X	X
Marine Mammals	X		X	X	X			
Riverine Mammals	X		X	X				
Marine Turtles	X			X	X			
Marine Fish	X	X	X		X			
Marine Benthos	X	X	X					
Ecological Balance and Ecosystems	X	X	X		X			
Socioeconomic Resources/Receptors								
Economic Conditions/ Employment and Livelihoods	X		X	X				
Community Health and Wellbeing	X		X	X		X		
Marine Use and Transportation	X		X	X				

Resource/Receptor	Oil Spill		Coastal Fuel Spill	Vessel Collision [a]	Discharge of Untreated Wastewater from the FPSO	Vehicular Accident	Collision between Seabird and Project Vessel or Helicopter	Seabird Collision with FPSO Flare Tower, Flame, or Radiant Heat Plume
	Marine	NADF						
Social Infrastructure and Services	X		X			X		
Waste Management Infrastructure and Capacity	X		X					
Cultural Heritage	X	X	X					
Land Use	X		X					
Ecosystem Services	X		X					
Indigenous Peoples	X							

[a] This scenario focuses on non-spill related impacts; fuel and crude oil spills from vessel accidents are addressed in the “Oil Spill” columns.

9.1.17. Embedded Controls and Mitigation Measures for Unplanned Events

Table 9.1-7 lists the embedded controls and mitigation measures relevant to the unplanned events described above.

Table 9.1-7: List of Embedded Controls and Mitigation Measures for Unplanned Events

Embedded Controls	Related Unplanned Event
Use water-based drilling fluids to the extent reasonably practicable (upper sections of the wells). For well sections requiring NADF, use only low-toxicity International Oil and Gas Producers Group III base fluid.	NADF release
Install a BOP system that can be closed rapidly in the event of an uncontrolled influx of formation fluids and that allows the well to be circulated to safety by venting the gas at surface and routing oil so that it may be contained.	Marine oil spill
Test BOP equipment at installation, after disconnection or repair of any pressure containment seal, and at regular intervals (at least every 21 days or as operations allow).	Marine oil spill
With respect to prevention of spills of hydrocarbons and chemicals during the drilling stage: • Change liquid hydrocarbon transfer hoses periodically; • Use dry-break connections on liquid hydrocarbon bulk transfer hoses; • Perform required inspections and testing of all equipment prior to deployment/installation; • Use overbalanced drilling fluids to control wells while drilling; • Perform operational training certification (including well-control training) for drill ship supervisors and engineers; • Regularly audit field operations on the drill ships to ensure application of designed safeguards; • Use controls for mitigating a failure of the DP system on the drill ships and maintaining station-keeping, which include: – Use of a Class 3 DP system, which includes numerous redundancies – Rigorous personnel qualifications and training – Sea trials and acceptance criteria – DP proving trials – System Failure Mode and Effects Analysis – DP failure consequence analysis • Establishment of well-specific operations guidelines	Marine oil spill
Maintain marine safety exclusion zones to be issued through the MARAD with a 500-meter (approximately 1,640-foot) radius around drill ships and major installation vessels, to prevent unauthorized vessels from entering areas with an elevated risk of collision.	Vessel collision with a third-party vessel
Use leak detection systems for equipment, treatment, and storage facilities (fuel, chemical, etc.) on drill ships in accordance with good international oilfield practice.	Marine oil spill
Use leak detection controls during installation and operation of SURF equipment (e.g., pigging and pressure testing of lines, periodic ROV surveys of subsea trees, manifolds, flowlines, and risers).	Marine oil spill

Instead of continuous flaring of gas produced during crude oil production, re-inject associated gas that is not used as fuel gas on the FPSO into the reservoir, to avoid routine flaring of associated gas.	Seabird collision with FPSO flare tower, flame, or radiant heat plume
Maintain marine safety exclusion zones to be issued through the Maritime Administration Department with a 2-nautical-mile (approximately 12,150-foot) radius around FPSO during offloading operations, to prevent unauthorized vessels from entering areas with an elevated risk of collision.	Vessel collision with a third-party vessel, marine oil spill
Employ dedicated Mooring Master to supervise offloading activities, according to the conditions of the sea. The conditions and characteristics of the export tankers will be assessed by the Mooring Master and reported to the Offshore Field Manager prior to commencing offloading operations. Use only properly registered and well-maintained double-hull vessels.	Vessel collision with a third-party vessel, marine oil spill
Use support tugs to aid tankers in maintaining station during approach/departure from FPSO and during offloading operations.	Vessel collision with a third-party vessel, marine oil spill
Use a hawser with a quick release mechanism to moor the FPSO to the tanker at a safe separation distance during offloading operations.	Vessel collision with a third-party vessel, marine oil spill
Establish operating conditions for FPSO offloading to tankers to support safe operations. In the event that adverse weather occurs during offloading operations that is beyond the environmental operating limit, the tanker will cease offloading operations, and may disconnect and safely maneuver away from the FPSO as appropriate.	Vessel collision with a third-party vessel, marine oil spill
Use breakaway couplers on offloading hose that would stop the flow of oil from FPSO during an emergency disconnect scenario.	Marine oil spill
Use a load-monitoring system in the FPSO control room to support FPSO offloading.	Marine oil spill
Use leak detection controls during FPSO offloading (e.g., for breach of floating hose, instrumentation/procedures to perform volumetric checks).	Marine oil spill
Inspect and maintain onboard equipment (engines, compressors, generators, sewage treatment plant, and oil-water separators) in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, to maximize efficiency and minimize malfunctions, and unnecessary discharges into the environment.	Marine oil spill, coastal fuel spill, discharge of untreated wastewater from the FPSO
Equip Project vessels with radar systems and communication mechanisms to communicate with third-party mariners.	Vessel collision with a third-party vessel, coastal fuel spill
Regularly inspect and service shorebase cranes and construction equipment to mitigate the potential for spills and to reduce air emissions to the extent reasonably practicable.	Coastal fuel spill
Use secondary containment for storage of bulk fuel, drilling fluids, and hazardous materials, where practicable.	Marine oil spill
Regularly (e.g., monthly) check pipes, storage tanks, and other equipment associated with storage or transfer of hydrocarbons/chemicals for leaks.	Marine oil spill, coastal fuel spill, discharge of untreated wastewater from the FPSO
Provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals and riverine mammals at the sea surface. Provide standing instruction to Project-dedicated vessel masters to avoid marine mammals, riverine mammals, and marine turtles while underway and reduce speed or deviate from course, when possible, to reduce probability of collisions.	Vessel collisions with marine mammals, marine turtles, and riverine mammals
Provide standing instruction to Project-dedicated vessel masters to avoid any identified rafting seabirds when transiting to and from the PDA.	Vessel collisions with seabirds

Provide standing instructions to Project-dedicated vessel masters to reduce their speed within 300 meters (984 feet) of observed marine mammals and marine turtles, and to not approach the animals closer than 100 meters (328 feet).	Vessel collisions with marine mammals and marine turtles
Observe standard international and local navigation procedures in and around the Georgetown Harbour and Demerara River, as well as best ship-keeping and navigation practices while at sea.	Vessel collision with a third-party vessel, coastal fuel spill
Implement a Road Safety Management Procedure to mitigate increased risk of vehicular accidents associated with Project-related ground transportation activities. The procedure will include, at a minimum, the following components: • Definition of typical, primary travel routes for ground transportation in the Georgetown area; • Development of an onshore logistics/journey management plan to reduce potential conflicts with local road traffic when transporting goods to/from onshore support facilities; • Definition of required driver training for Project-dedicated drivers, including (but not limited to) defensive driving, loading/unloading procedures, and safe transport of passengers, as applicable; • Designation and enforcement of speed limits through speed governors, global positioning system, or other monitoring systems for Project-dedicated vehicles; • Avoidance of deliveries during typical peak-traffic hours as well as scheduled openings of the Demerara Harbour Bridge, to the extent reasonably practicable; • Monitoring and management of driver fatigue; • Definition of vehicle inspection and maintenance protocols that include all applicable safety equipment for Project-dedicated vehicles; and • Community outreach to communicate information relating to major delivery events or periods.	Vehicular accident
Maintain an OSRP to ensure an effective response to an oil spill, including maintaining the equipment and other resources specified in the OSRP and conducting periodic training and drills.	Marine oil spill, coastal fuel spill
Mitigation Measures	**Related Unplanned Event**
Issue Notices to Mariners to the Trawler's Association and fishing co-ops via the MARAD for movements of major marine vessels (including the FPSO, drill ship, and installation vessels) to facilitate their avoidance of areas with concentrations of Project vessels and/or where marine safety exclusion zones are active.	Vessel collision with a third-party vessel, marine oil spill
Augment ongoing stakeholder engagement process (along with relevant authorities) to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners and, where possible, communicate with them regarding major vessel movements and marine safety exclusion zones.	Vessel collision with a third-party vessel, marine oil spill
Promptly remove damaged Project vessels (associated with any vessel incidents) to minimize impacts on marine use, transportation, and safety.	Vessel collision with a third-party vessel
Implement the OSRP in the unlikely event of an oil spill, including: • Conducting air quality monitoring during emergency response; • Requiring use of appropriate PPE by response workers; and • Implementing a Wildlife Oil Response Program, as needed.	Marine oil spill, coastal fuel spill

Implement a claims process and, as applicable, a livelihood remediation program to address economic losses or impacts on livelihood as a result of an oil spill.	Marine oil spill, coastal fuel spill
In case of a collision involving a Project vessel and a non-Project vessel that may result in a claim arising from such type of incident, provide appropriate restitution, consistent with governing contracts and applicable laws.	Vessel collision with a third-party vessel

PPE = personal protective equipment

9.2. AIR QUALITY, CLIMATE, AND CLIMATE CHANGE

As indicated in Table 9.1-6, the unplanned events with the potential to result in measurable impacts to air quality or climate include a marine oil spill and a coastal fuel spill. A reasonable worst-case estimate for non-routine flaring emissions, while not planned to occur, has been analyzed and is presented in Section 6.1.

9.2.1. Marine Oil Spill

9.2.1.1. Air Quality

Crude oil is a mixture of hydrocarbons, and is made up of light, medium, and heavy constituents. In the unlikely event of an oil spill, the lighter hydrocarbons in the spilled oil (including benzene, xylenes, and toluene) tend to quickly evaporate into the air. Additionally, the oil that would be released from a spill in the PDA would be a medium crude oil. Medium crude oils such as those that will be produced by the Project contain less of the aromatic hydrocarbons than are found in light crude oils (National Academies of Sciences, Engineering, and Medicine 2016). Accordingly, atmospheric concentrations of these constituents associated with the spilled oil typically drop rapidly during the first 24 hours of a spill (Gros et al. 2014). Elevated hydrocarbon concentrations in air are primarily found in the immediate vicinity of a spill and some distance downwind, depending on wind speeds. Atmospheric concentrations would thus primarily be a source of potential impact for oil spill response workers; air-monitoring equipment would be deployed to monitor levels of air pollutants and appropriate personal protective equipment would be provided, as necessary, to those oil spill response workers who have the potential to be exposed. The remainder of this discussion is therefore focused on risk to potential onshore (community) receptors in Guyana.

Considering the above, in the case of a marine oil spill, the potential for potentially harmful concentrations of air contaminants to reach the Guyana coastline (where potential receptors could be located) is considered very low, even for a loss-of-well-control release, considering the distance to shore from the hypothetical source of such a spill (approximately 203 kilometers [126 miles] northeast of the coastline of Georgetown) and the reduction in emissions coming off the oil slick that would occur as the oil slick spreads. This expectation is supported by a study on air emissions associated with the Deepwater Horizon Spill, where most of the lighter hydrocarbons (smaller than C4 alkanes and C6–C7 aromatics) released from the well head—at about 1,500 meters (4,021.3 feet) below the sea surface—were dissolved in the water column before reaching the surface. As a result, the concentrations of volatile constituents

(e.g., benzene, toluene, and to a lesser extent other aromatics) in the air above the spill were lower than would have been expected for a shallow-water or surface spill, and the spill was also far enough offshore that there was dispersion of the constituents before they reached populated areas (Middlebrook et al. 2012). Accordingly, it is expected that even in the event of a marine oil spill reaching or coming near a Guyana shoreline, elevated atmospheric concentrations of air contaminants in areas with potential onshore human receptors would be localized to areas close to where the oil came ashore or near the shore.

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Stochastic modeling for both scenarios indicates a 5 to 40 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 1 and a 5 to 10 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 2, depending on wind and current conditions at the time of the spill. Deterministic oil spill modeling for both loss-of-well-control scenarios, selecting scenarios based on the predicted time for a spill to reach a shoreline[5], predicts that an unmitigated oil spill would remain well offshore of Guyana for the Most Credible WCD scenario during both modeled seasons and for the (Jun–Nov) Maximum WCD scenario, but predicts impact across the majority of the Region 1 shoreline for the (Dec–May) Maximum WCD scenario. Considering mitigation, deterministic modeling for the (Dec–May) Maximum WCD scenario predicts a reduction in the predicted length of shoreline impact in Region 1, but the predicted length still represents the majority of the Region 1 shoreline. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

Deterministic modeling for the Most Credible WCD scenario predicts that an unmitigated spill would come within approximately 75 kilometers (approximately 47 miles) of the Guyana shoreline. As noted above, deterministic modeling for the Maximum WCD scenario predicts that an unmitigated spill would reach the Guyana shoreline in Region 1 under the (Dec–May) scenario.

On the basis of the predicted spill trajectories for the deterministic modeling of the loss-of-well-control scenarios described above, and considering that atmospheric emissions from the spilled oil would have reduced significantly as the spill migrates and weathers, the intensity of potential impacts to onshore Guyana air quality from an unmitigated marine oil spill would be **Negligible**. The geographic extent of air quality impacts of an unmitigated loss-of-well-control event would include limited portions of the **Indirect AOI**. On the basis that air quality impacts from an unmitigated loss-of-well-control event would persist for as long as the spill remained unmitigated (albeit with gradually reducing emissions as the oil weathers), the frequency is considered to be **Continuous**. Air quality impacts, even assuming no mitigation of the spill, would reduce significantly with time as the oil continued to weather, so duration is considered to be no more than **Medium-term**. Applying the methodology described in Chapter 4, Methodology for

[5] Deterministic modeling was conducted for each scenario for a simulated spill date that represents the 95th percentile for minimum time to shore from all the stochastic spill scenarios simulated that had a greater than 5 percent probability of reaching shore.

Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Negligible**.

As noted in the discussion of potential air quality impacts from planned activities, the sensitivity of most potential onshore receptors to atmospheric emissions is considered **Medium**, with the potential for some receptors to have a **High** sensitivity. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**.

In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall pre-mitigation risk to onshore Guyana air quality from an unmitigated marine oil spill would be **Minor** (see Table 9.2-1).

With implementation of the OSRP, deterministic modeling for the Most Credible WCD and Maximum WCD both predict that the closest distances a mitigated spill would come to a Guyana shoreline are greater than those predicted for an unmitigated spill for all but the (Dec–May) Maximum WCD scenario, for which the predictions are roughly equivalent to that of the unmitigated spill scenario. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts. On this basis, the intensity of potential impacts to onshore Guyana air quality from a mitigated marine oil spill would be **Negligible** for both spill scenarios considered. This leads to a magnitude rating of **Negligible**, maintaining the consequence/severity rating to **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall residual risk to onshore Guyana air quality from an unmitigated marine oil spill would remain **Minor** (see Table 9.2-1).

9.2.1.2. Climate and Climate Change

With respect to potential climate impacts from a marine oil spill, there would be a potential indirect impact associated with additional fossil fuel combustion by response vessels and fuel-fired equipment involved with the response effort, resulting in increased greenhouse gas (GHG) emissions as compared to that associated with planned Project activities. As supported by a study of estimated carbon dioxide emissions from global marine oil spills, which concluded that on a per megajoule basis, these emissions are so low as to be negligible from the point of view of setting baseline fossil fuel emissions intensity (Malins et al. 2013), the scale of these additional GHG emissions would likely represent a very small incremental increase, leading to a consequence/severity rating with respect to risks to climate of **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall risk to climate from a marine oil spill would be **Minor** (see Table 9.2-1).

9.2.2. Coastal Fuel Spill

9.2.2.1. Air Quality

In the case of a coastal fuel spill, the potential for potentially harmful concentrations of air contaminants to reach the Guyana coastline (where potential receptors could be located) is higher than for a marine oil spill (based on the assumed closer proximity of the spill to potential onshore receptors and the higher concentration of volatile organics in a diesel fuel as compared

to a crude oil), but the spill volume (and thus affected surface area) would be expected to be significantly smaller than the loss-of-well-control scenario considered for a marine oil spill. Elevated concentrations of air contaminants in areas with potential human receptors would be localized to the nearshore area alongside the spilled fuel.

Balancing the closer proximity of a coastal fuel spill to potential receptors with the reduced volume of such a spill, the intensity of potential impacts to onshore Guyana air quality from an unmitigated coastal fuel spill could be as much as **Medium**. The geographic extent of an unmitigated coastal fuel spill event would likely be limited to the **Direct AOI**. On the basis that air quality impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled fuel weathers), and because an unmitigated coastal fuel spill could—depending on volume of release—be present on the water more than a week, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

As noted in the discussion of potential air quality impacts from planned activities, the sensitivity of most potential onshore receptors to atmospheric emissions is considered **Medium**, with the potential for some receptors to have a **High** sensitivity. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Medium** to **High**.

In combination with a likelihood rating of **Unlikely** for a coastal fuel spill, the overall pre-mitigation risk to onshore Guyana air quality from an unmitigated coastal fuel spill would be **Minor** to **Moderate** (see Table 9.2-1).

With implementation of the OSRP, the intensity of potential impacts to onshore Guyana air quality from a mitigated coastal fuel spill would be reduced to the range of **Negligible** to **Low** (depending on the size of the spill), based on the expectation that these types of spills would typically involve non-persistent oils that can typically be relatively quickly mitigated. This leads to a magnitude rating of **Negligible** to **Small**, reducing the consequence/severity rating to a range of **Low** to **Medium**. In combination with a likelihood rating of **Unlikely** for a coastal fuel spill, the overall residual risk to onshore Guyana air quality from an unmitigated coastal fuel spill would be **Minor** (see Table 9.2-1).

9.2.2.2. Climate and Climate Change

As with a marine oil spill, potential risk to climate from a coastal fuel spill would stem from a potential indirect impact associated with additional fossil fuel combustion by response vessels and fuel-fired equipment, resulting in increased GHG emissions. However, the scale of these additional GHG emissions would be limited in magnitude and time, leading to a consequence/severity rating with respect to impacts on climate of **Low**. In combination with a likelihood rating of **Unlikely** for a marine or coastal fuel spill, the overall risk to climate from a coastal fuel spill would be **Minor** (see Table 9.2-1).

Table 9.2-1: Risk Ratings for Unplanned Event Impacts on Air Quality, Climate, and Climate Change

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Air Quality (onshore Guyana)	Unlikely	Low	Minor	Implement OSRP	Minor
	Climate	Unlikely	Low	Minor	Implement OSRP	Minor
Coastal Fuel Spill	Air Quality (onshore Guyana)	Unlikely	Medium to High	Minor to Moderate	Implement OSRP	Minor
	Climate	Unlikely	Low	Minor	Implement OSRP	Minor

9.3. MARINE GEOLOGY AND SEDIMENTS

As indicated in Table 9.1-6, the unplanned events with the potential to result in measurable impacts on marine sediments include a marine oil spill, a coastal fuel spill, and an NADF release.

9.3.1. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Stochastic modeling for both scenarios indicates a 5 to 40 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 1 and a 5 to 10 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 2, depending on wind and current conditions at the time of the spill. Deterministic oil spill modeling for both loss-of-well-control scenarios, selecting scenarios based on the predicted time for a spill to reach a shoreline[6], predicts that an unmitigated oil spill would remain well offshore of Guyana for the Most Credible WCD scenario during both modeled seasons and for the (Jun–Nov) Maximum WCD scenario, but predicts impact across the majority of the Region 1 shoreline for the (Dec–May) Maximum WCD scenario. Considering mitigation, deterministic modeling for the (Dec–May) Maximum WCD scenario predicts a reduction in the predicted length of shoreline impact in Region 1, but the predicted length still represents the majority of the Region 1 shoreline. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

Most of the oil released from a marine oil spill would be expected to rapidly reach the water surface, but a portion of the oil may adhere to suspended solids in the water column and settle to the bottom, which could impact marine sediments. Significant concentrations of suspended solids in the water column are often necessary for this to occur. In the open marine environment, suspended solids concentrations are generally low (less than 10 mg/L). However, based on environmental baseline survey sampling performed by EEPGL between 2014 and

[6] Deterministic modeling was conducted for each scenario for a simulated spill date that represents the 95th percentile for minimum time to shore from all the stochastic spill scenarios simulated that had a greater than 5 percent probability of reaching shore.

2019, some areas offshore Guyana have had concentrations on the order of 50 mg/L. Additionally, especially in large spills, biological material (e.g., zooplankton, phytoplankton) may also serve as a substrate for oil adsorption and subsequent settling. “Marine snow,” a phenomenon that is a result of naturally occurring decaying remnants of zooplankton, phytoplankton, and other detritus and small fecal pellets that can form sticky clusters, has been observed to bind with oil and settle during an oil spill (Joye et al. 2016). In the case of the Deepwater Horizon incident, it is theorized that the spill generated a phenomenon where the marine snow observed during the active release became exceptionally sticky from stressed phytoplankton due to the spill, adhered to suspended solids and oil beneath the slick, and settled across the seafloor. In the case of a deep-sea blowout, as was the case during the Deepwater Horizon incident, the source of sediment contamination may not be limited to only the oil that reaches the surface. Small oil droplets from the rising plume may divert and become trapped at certain depth layers and continue to travel horizontally with the currents (Brooks et al. 2015). Marine snow may contact the oil at these depths, creating a separate source for sediment contamination travelling within the water column.

Sediment cores collected more than 200 kilometers (124.3 miles) away from the Deepwater Horizon riser and Macondo wellhead showed evidence of distinct manganese oxide spikes that were attributed to a rapid sedimentation rate of materials from the surface during the 4- to 5-month period of the Macondo reservoir fluid release and transport (Brooks et al. 2015). While a large region of the Gulf of Mexico showed evidence of increased sedimentation, assumed to be from the marine snow, not all deposits in the sediment during the spill were associated with detectable benthic impacts. Areas with identified “moderate to severe” impacts to benthos were found to be localized and centered around the wellhead, covering an area of approximately 263 km² (approximately 64,988.5 acres), and measuring on the order of 33 kilometers (21.5 miles) across (Reuscher et al. 2020).

It is important to note that the Deepwater Horizon examples used here as reference include the effects from a mitigated spill with both subsurface and surface application of dispersants. Application of dispersants as part of mitigation efforts could reduce the surface slick area, volume, and duration of the spill, but application of dispersants during mitigation efforts could also promote the plankton mucous production (Joye et al. 2016), thereby increasing sediment contamination. Thus for an unmitigated marine spill event, it is expected that while the marine snow phenomenon event would be decreased, a larger area would be contacted by the spill; accordingly, for the purpose of this assessment, the intensities of a mitigated and unmitigated event are assumed to be equivalent.

Impacted sediment quality can potentially impact the biota living in the sediment, and thus the assessment of intensity for sediment quality impacts is characterized considering these follow-on impacts to marine benthos. The intensity of potential impacts of an unmitigated marine oil spill on marine sediment quality is thus considered to be up to **High**. The geographic extent of an unmitigated loss-of-well-control event could encompass portions of the **Indirect AOI**. On the basis that impacts on marine sediments from an unmitigated loss-of-well-control event would persist as long as oil-impacted settled material remained in contact with marine sediments, the frequency is considered to be **Continuous**. Even without mitigation, currents would redistribute

the settled material, and the settled material would degrade over time; however, as a conservative measure, it was assumed for the purpose of the assessment that impacts could persist more than a year, yielding a **Long-term** duration. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**.

While the benthic community in the Yellowtail PDA is characterized as Low sensitivity, studies in other portions of the Stabroek Block (e.g., north of the Yellowtail PDA and in the Payara PDA) have shown evidence of hard seafloor features (HSFs). The most sensitive component of the benthic community to elevated contaminant concentrations is likely to be the sponges living on these HSFs (Vad et al. 2018). Although the sponge-dominated community would be more sensitive to elevated contaminant concentrations than the rest of the benthic community that would potentially be impacted by sediment contamination resulting from a loss-of-well-control event, it is expected that the HSF community accounts for a small portion of the seafloor in the area that could be affected. Therefore, a small fraction of the overall benthic community would be expected to have a higher sensitivity to elevated sediment contamination, and the overall sensitivity of marine benthos (used to represent sediment quality sensitivity for this assessment) is rated as **Medium**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the pre-mitigation risk to marine benthos is considered **Moderate**.

Although there is little in the way of mitigation that would further reduce the potential impacts of a marine oil spill on marine sediment in proximity to the well, EEPGL has a number of embedded controls to prevent a spill from occurring, and implementation of the OSRP would reduce the level of impact if a spill were to occur. However, despite this reduction, and with the assumed inclusion of dispersants applied during mitigation—which may increase sediment quality impacts in a localized area around the wellhead—the intensity of potential impacts on marine sediment quality from a mitigated marine oil spill is assumed to remain **High**. The frequency would remain unchanged at **Continuous**. The duration would likely be reduced to no more than **Medium-term**. This maintains the magnitude rating of **Large** and the consequence/ severity rating of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall residual risk to marine sediment quality from a mitigated marine oil spill would be maintained at **Moderate** (see Table 9.3-1).

9.3.2. Coastal Fuel Spill

In the unlikely event of a coastal fuel spill, the fuel would not sink or accumulate on the seafloor unless adsorption occurs with sediment; however, it is possible for fuel that is dispersed by wave action to form droplets that are small enough to be kept in suspension and moved by the currents. The oil dispersed in the water column and the dissolved components of that oil can adhere to fine-grained suspended sediments, which can then settle out and deposit on the seafloor. This is less likely to occur in open marine settings, and is not likely to result in measurable sediment contamination for small spills (NOAA 2020). Accordingly, the intensity of

such an impact on marine sediments, if it were to occur, would be considered **Low**. The geographic extent of an unmitigated coastal fuel spill event could potentially include portions of the **Indirect AOI**, assuming the spill is large enough to migrate outside of the Project transit corridor. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled fuel weathers), and because the impacts of an unmitigated coastal fuel spill could—depending on volume of release—continue over several weeks, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude of **Medium**. Using the definitions for sensitivity rating presented in the assessment of potential impacts on marine geology and sediments from planned Project activities, a sensitivity rating of **Low** is assigned. Therefore, applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a coastal fuel spill is considered **Unlikely**, so the overall risk to marine sediments from a coastal fuel spill would be **Minor** (see Table 9.3-1).

9.3.3. NADF Release

In the unlikely event of an emergency disconnect of the drilling riser and hypothetical release of NADF near the seafloor, cuttings would also be released. The majority of the non-aqueous base fluid (NABF) in the NADF would separate and rise to the surface, whereas the remaining portions of the NADF would settle and accumulate on the seafloor. Cuttings deposits would tend to be deeper and coarser in the immediate vicinity of the wellhead, and would decrease in thickness and grain size with increasing distance from the wellhead. The strength of the bottom currents in the PDA would likely transport any significant fines from deposition near the wellhead, dispersing all but the coarsest cuttings down-current. A potential physical effect would be a change in the grain-size distribution within the deposition field, although this effect would tend to diminish over time, as benthic infauna and natural sediment deposition would gradually bury the deposited cuttings. Another potential physical effect would be addition of hydrocarbons to the sediments as a result of settled portions of the NADF. The concentrations of hydrocarbons in the sediment would gradually decrease through biological degradation. This process could result in localized decreases in dissolved oxygen concentrations in the pore water between the cuttings grains deposited on the seafloor. Organic enrichment of sediments speeds the biodegradation process, which tends to accelerate oxygen depletion. Conditions favoring eutrophication[7] and hypoxia[8] in the near-surface pore water within the deposition zone may exist temporarily following a release of NADF. Eutrophication and resulting hypoxia at the seafloor or within the pore water could be sufficient to cause effects to marine biota in the sediment.

The NADF to be used by the Project will contain International Association of Oil and Gas Producers (IOGP) Group III NABF, with low to negligible aromatic content, and with higher

[7] Over-enrichment of a waterbody with minerals and nutrients that can induce excessive growth of plants (including phytoplankton) or algae
[8] Deficiency in dissolved oxygen concentrations

biodegradation rates than lower-grade NABF. This reduces the potential that changes in marine sediment chemistry as a result of discharge of the NADF would lead to toxicological impacts on benthic infauna.

Using the definitions in Table 6.3-10, the intensity of potential impacts of an NADF release on marine sediments is considered **Low**. The geographic extent of an unmitigated NADF release would likely be limited to the **Direct AOI**. On the basis that impacts on marine sediments from an unmitigated NADF release would persist as long as it was exposed to the spilled material, the frequency is considered to be **Continuous**. Even without mitigation, currents would redistribute the spilled material, and the spilled material would degrade over time; however, as a conservative measure, it was assumed for the purpose of the assessment that impacts could persist more than a year, yielding a **Long-term** duration. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**.

Using the definitions for sensitivity rating presented in the assessment of potential impacts on marine geology and sediments from planned Project activities, and on the basis that the HSFs that have been found elsewhere in the Stabroek Block have been found to not be present in the area where an NADF release could occur, a sensitivity rating of **Low** is assigned. Therefore, applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, an NADF release is considered **Unlikely**, so the overall risk to marine sediments from an NADF release would be **Minor** (see Table 9.3-1).

Depending on the nature of the event, actions could be taken by the drill ship to reduce the volume of NADF released. In this case, the release could be smaller in volume and the impacts would be shorter in duration than for the unmitigated scenario described above. Conservatively, however, it is assumed that the intensity rating would remain **Low**. The magnitude rating thus remains **Small** and the consequence/severity rating remains **Low**. In combination with a likelihood rating of **Unlikely** for the accidental release of NADF, the overall residual risk to marine sediments from a mitigated release of NADF would be **Minor** (see Table 9.3-1).

Table 9.3-1: Risk Ratings for Unplanned Event Impacts on Marine Geology and Sediments

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Ranking	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Sediments	Unlikely	High	Moderate	Implement OSRP	Moderate
Coastal Fuel Spill	Coastal Sediments	Unlikely	Low	Minor	Implement OSRP	Minor
NADF Release	Marine Sediments	Unlikely	Low	Minor	Implement OSRP	Minor

9.4. MARINE WATER QUALITY

As indicated in Table 9.1-6, the unplanned events with the potential to result in measurable impacts on marine water quality include a marine oil spill, a coastal fuel spill, an NADF release, and a discharge of untreated wastewater from the FPSO.

9.4.1. Marine Oil Spill

As described in Section 9.1.3, Weathering Process, marine oil spills are subject to a range of weathering processes. These processes result in the oil partitioning into different phases (entrained, bubbles, etc.) of the marine environment, while experiencing dilution. Some of the spilled oil is removed from the water column via evaporation and photo-oxidation[9]. Additionally, biodegradation processes gradually reduce hydrocarbon concentrations in the marine environment following a spill. The proportion of the spill that mixes[10] through the water column due to wave energy is subject to rapid, high levels of dilution along with this biodegradation. Some oil constituents, especially aromatics, are also soluble in water. The proportion of the spill that mixes through the water can increase hydrocarbon concentrations in the water column and result in temporary changes to water quality.

Potential impacts on water quality from a marine oil spill are thus related to contamination within the water column from dissolved hydrocarbon concentrations (primarily polycyclic aromatic hydrocarbons [PAH]). While contamination in the water column from a spill can be brief, a release from an unmitigated loss-of-well-control event can cause a persistence of elevated concentrations until the release is controlled. Oil spill monitoring has shown that concentrations of oil and its constituents in the water column rapidly decline after a spill, and are usually confined to an area near the origin of the spill (ITOPF 2014). The oil that would be released from a spill in the PDA would be a medium crude oil. Medium crude oils contain less of the water-soluble, aromatic hydrocarbons than are found in light crude oils. However, as a result of the lower evaporation, dispersion, and dissolution in seawater, medium crude oils are more persistent in the environment relative to light crude oils. The medium crude oil would produce fewer biological effects than light crude oil, but its higher persistence relative to light crude oil increases the importance of focusing the spill response on reducing or eliminating shoreline stranding. It is also noted that the mixing energy resulting from a loss-of-well-control event may result in higher levels of entrained and dissolved hydrocarbons than would be associated with a surface spill, as the oil would tend to be fragmented into smaller droplets as a result of the reservoir pressure.

Accordingly, the intensity of impacts on water quality from a marine oil spill from an unmitigated loss-of-well-control event is considered **High** at the locations with the greatest dissolved aromatic concentrations. The geographic extent of an unmitigated loss-of-well-control event would include portions of the **Indirect AOI**. The impact on marine water quality would persist as long as the oil spill is present in the water, so the frequency is considered to be **Continuous**. The effects, assuming no mitigation of the spill, would have the potential to extend beyond a

[9] Process of chemical breakdown caused by exposure to sunlight
[10] Mixing is achieved by a combination of entrainment and dissolution.

year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**.

As discussed in Section 6.4.3.3, Characterization of Impacts—Changes to Water Quality and Temperature, the definitions for sensitivity ratings for marine water quality impacts from effluent discharges take into account the sensitivity of marine biota that can experience indirect impacts from a change in water quality. While it is expected that there are groups of marine biota that will have sufficient mobility to avoid regions of elevated concentrations, it is conservatively assumed for the purpose of this assessment that some species will have limited mobility and ability to avoid areas with impacted water quality. Accordingly, a sensitivity rating of **Medium** is assigned (see Table 6.4-13). Applying the methodology in Chapter 4, the magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. This takes into consideration the higher toxicity of the light oil fractions and the magnitude and extent of the spill scenario, balanced against the limited geographic extent and duration of the toxicity impacts as a result of the relatively rapid loss of lighter fractions. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall risk to marine water quality from a marine oil spill is rated as **Moderate**. Even with implementation of the OSRP, the residual risk rating would conservatively remain **Moderate** (see Table 9.4-1).

9.4.2. Coastal Fuel Spill

With respect to the coastal fuel oil spill scenario, a spill of fuel would also contain higher-toxicity light oil fractions, but the scenario would have a smaller volume, limited geographic extent, and shorter duration of toxicity impacts, as compared to the marine oil spill scenario. These factors lead to an intensity rating of **Medium**. The geographic extent of an unmitigated coastal fuel spill event could potentially include portions of the **Indirect AOI**, assuming the spill is large enough to migrate outside of the Project transit corridor. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the oil spill weathers), and because the impacts of an unmitigated coastal fuel spill could—depending on volume of release—continue over several weeks, the frequency and duration are considered to be **Continuous** and **Medium-term**. Therefore, applying the methodology described in Chapter 4, these characteristics lead to an overall magnitude rating of **Medium**.

As discussed in Section 6.4.3.3, the definitions for sensitivity ratings for marine water quality impacts from effluent discharges take into account the sensitivity of marine biota that can experience indirect impacts from a change in water quality. While it is expected that there are groups of marine biota that will have sufficient mobility to avoid regions of elevated concentrations, it is conservatively assumed for the purpose of this assessment that some species will have limited mobility and ability to avoid areas with impacted water quality. Accordingly, a sensitivity rating of **Medium** is assigned (see Table 6.4-13).

Applying the methodology in Chapter 4, the magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium** with respect to impacts on water quality. In combination with a likelihood rating of **Unlikely** for a coastal fuel spill, the overall risk to marine

water quality from a coastal fuel spill is **Minor**. Even with implementation of the OSRP, the residual risk rating would remain **Minor** (see Table 9.4-1).

9.4.3. NADF Release

In the unlikely event of an emergency disconnect of the drilling riser and hypothetical release of NADF near the seafloor, NADF would start to undergo biological degradation after being released from the drilling riser. This process could result in localized decreases in dissolved oxygen concentrations, although this is more likely to be observed in the pore water between the cuttings grains deposited on the seafloor than in the water column, due to the dissolution of NADF in the water column caused by the strong marine currents in the region. Organic enrichment of sediments speeds the biodegradation process, which tends to accelerate oxygen depletion, and NADF cuttings tend to contain higher concentrations of biodegradable matter than WBDF. Conditions favoring eutrophication[11] and hypoxia[12] in the near-surface pore water within the deposition zone may exist temporarily following a release of NADF. Eutrophication and resulting hypoxia at the seafloor or within the pore water could be sufficient to cause effects to marine biota, but these changes would likely be short-term in nature. From a toxicological perspective, although the NADF used by the Project will contain IOGP Group III NABF, it will have low to negligible aromatic content, and with higher biodegradation rates than lower-grade NABF—reducing the potential that changes in marine water quality as a result of discharge of the NADF would lead to toxicological impacts on marine biota.

Using the definitions in Table 6.4-7, the intensity of potential impacts of an NADF release on marine water quality would likely be no more than **Medium**. The geographic extent of an unmitigated NADF release would be limited to the **Direct AOI**. On the basis that impacts on marine water quality from an unmitigated NADF release would persist as long as the spilled material was in contact with the water column (noting that concentrations would decline over time as a result of mixing and biodegradation), the frequency is considered to be **Continuous**. Even without mitigation, currents would result in the spilled material being dispersed such that elevated concentrations in the water column would be expected to persist less than a year, yielding no more than a **Medium-term** duration. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

As discussed in Section 6.4.3.2, Characterization of Impacts—Increased TSS from Drill Cuttings Discharge, the definitions for sensitivity ratings for marine water quality from a drill cuttings discharge take into account the sensitivity of marine biota that can experience indirect impacts from a change in water quality. The portion of the water column that would be affected by an NADF release may support some species that are biologically vulnerable, but an NADF release would affect only a small portion of the area on which these species depend. Accordingly, a sensitivity rating of **Medium** is conservatively assigned (see Table 6.4-6). Therefore, applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 9.1.1.9, Summary of

[11] Over-enrichment of a waterbody with minerals and nutrients that can induce excessive growth of plants (including phytoplankton) or algae
[12] Deficiency in dissolved oxygen concentrations

Spill Scenarios Considered, an NADF release is considered **Unlikely**, so the overall risk to marine water quality from an NADF release would be **Minor** (see Table 9.4-1).

A mitigated release of NADF would be smaller in volume than an unmitigated release and the impacts would be shorter in duration than the unmitigated scenario described above, reducing the intensity rating to no more than **Low**. This leads to a magnitude rating of **Small** and a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for the accidental release of NADF, the overall residual risk to marine water quality from a mitigated release of NADF would be **Minor** (see Table 9.4-1).

9.4.4. Discharge of Untreated Wastewater from the FPSO

A discharge of untreated wastewater from the FPSO would only occur under an equipment failure scenario and would involve release of untreated wastewater directly overboard. Such a discharge would have localized impacts on marine water quality, but conditions that could cause such a release would generally be rectified within a short period of time. The primary constituents in wastewater include solids and biodegradable organics (usually measured in terms of biochemical oxygen demand), organic carbon, nutrients (primarily nitrogen and phosphorous), and pathogens such as coliform. As described in Section 9.1.11, Discharge of Untreated Wastewater from the FPSO, modeling of an untreated wastewater release scenario shows that the release would result in an area less than 10 meters (32.8 feet) from the discharge in which concentrations of biochemical oxygen demand, TSS, and fecal coliform would exceed the end-of-pipe levels recommended by the IMO's 2012 *Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants* (IMO 2012), and these concentrations would decline rapidly after cessation of the release.

The geographic extent of a discharge of untreated wastewater from the FPSO would be limited to a small portion of the **Direct AOI**. Using the definitions established for assessment of potential impacts on marine water quality from planned Project activities, the intensity of potential impacts of a discharge of untreated wastewater from the FPSO is considered **Low**. On the basis that impacts on marine water quality from a discharge of untreated wastewater form the FPSO would persist as long as the discharged material was in contact with the water column (noting that concentrations would decline over time as a result of mixing and biodegradation), the frequency is considered to be **Continuous**. The duration of this impact would be **Short-term**, as concentrations would decline rapidly to below recommended end-of-pipe discharge levels. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Small**.

As discussed in Section 6.4.3.3, the definitions for sensitivity ratings for marine water quality impacts from effluent discharges take into account the sensitivity of marine biota that can experience indirect impacts from a change in water quality. Given the extremely limited spatial extent and duration of elevated concentrations associated with a release of untreated wastewater, it is expected that marine biota will have sufficient mobility to avoid regions of elevated concentrations; accordingly, a sensitivity rating of **Low** is assigned (see Table 6.4-13).

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. Multiple redundancies in the FPSO's wastewater management system would have to fail simultaneously in order for untreated wastewater to be released to the environment, so such an event is considered **Unlikely**. These factors yield a pre-mitigation risk rating to marine water quality from a discharge of untreated wastewater from the FPSO of **Minor**.

Response actions would focus on identifying and rectifying the condition that caused the release rather than recovery of discharged material. The residual risk would remain **Minor** (see Table 9.4-1).

Table 9.4-1: Risk Ratings for Unplanned Event Impacts on Marine Water Quality

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Water Quality	Unlikely	High	Moderate	Implement OSRP	Moderate
Coastal Fuel Spill	Water Quality	Unlikely	Medium	Minor	Implement OSRP	Minor
NADF Release	Water Quality	Unlikely	Medium	Minor	Implement OSRP	Minor
Untreated Wastewater Discharge from FPSO	Water Quality	Unlikely	Low	Minor	None	Minor

9.5. PROTECTED AREAS AND SPECIAL STATUS SPECIES

As indicated in Table 9.1-6, the only unplanned event with the potential for measurable impacts on protected areas would be a marine oil spill. The only protected area that a marine oil spill would have the potential to impact would be the SBPA. Unplanned events with the potential for measurable impacts on special status species would include a marine oil spill, a coastal fuel spill, a discharge of untreated wastewater from the FPSO, and a collision of a Project vessel or helicopter with a seabird.

The assessments of impact significance for planned and unplanned events on marine turtles, riverine mammals, and marine turtles assume the affected receptors are all special status species, so potential risks of unplanned events on special status species in these taxonomic groups are assessed in Section 9.9, Marine Mammals, Section 9.10, Riverine Mammals, and Section 9.11, Marine Turtles, respectively and the impacts described for these special status species are not repeated in this section. Marine fish, seabirds, and coastal birds were not assessed on the basis of special status in separate planned or unplanned event sections of this EIA because most of the species in these taxa groups that occur in the PDA are not special status species. Hence, this section focuses on the impacts of unplanned events on the special status marine fish and bird (seabird and coastal bird) species known or expected to occur in the PDA that could be impacted by unplanned events.

9.5.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Section 7.1, Protected Areas and Special Status Species, contains the definitions for intensity of impact and sensitivity of receptor for impacts on protected areas and special status species. Table 7.1-6 contains descriptions of receptor sensitivity ratings for special status species.

9.5.1. Protected Areas

The only unplanned event with the potential for measurable impacts on protected areas would be a marine oil spill. As described in Section 9.1.5, Oil Spill Modeling Results, stochastic oil spill modeling for the Most Credible WCD and Maximum WCD scenarios indicates a 5 to 40 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 1 and a 5 to 10 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 2. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain offshore of Guyana for the Most Credible WCD scenario and for the Maximum WCD (Jun–Nov) scenario. Deterministic modeling predicts impact across the majority of the Region 1 shoreline for the (Dec–May) Maximum WCD scenario. Modeling mitigation under this scenario predicts a reduction in the predicted length of shoreline impact in Region 1, but the predicted length still represents the majority of the Region 1 shoreline. The deterministic modeling analysis does not predict shoreline impacts in Guyana outside of Region 1 for either the Most Credible WCD or Maximum WCD scenarios, regardless of season or the effects of mitigation.

Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

The Region 1 coastline contains the SBPA, which has high importance for biodiversity and related social values such as ecosystem services (see Section 7.1, Protected Areas and Special Status Species, and Section 8.9, Ecosystem Services). Coastal habitats within the SBPA, including mangrove forest, tidal and brackish wetlands, and sand beach, would be vulnerable to exposure to an oil spill because of their physical location adjacent to the surf zone. Based on the ecological sensitivity and importance of the SBPA, the intensity of potential impacts of an unmitigated marine oil spill on the SBPA is considered **High**. The geographic extent of an unmitigated loss-of-well-control event would encompass portions of the **Indirect AOI**. On the basis that impacts on coastal habitat from an unmitigated loss-of-well-control event would persist as long as the spill remained unmitigated, the frequency is considered to be **Continuous**. Even without mitigation, coastal habitat would gradually recover to some extent—depending on the degree of oiling—but impacts could still persist beyond a year, yielding a **Long-term** duration. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**.

The sensitivity of the SBPA in the areas with the potential to be affected by a marine oil spill is considered **High**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the pre-mitigation risk to the SBPA is considered **Moderate**.

Mitigation for a marine oil spill would involve implementation of the OSRP. Deterministic modeling for the Maximum WCD loss-of-well-control scenario predicts that a mitigated spill would reach Region 1 of the Guyana shoreline during a winter season spill, but not during the summer season. On this basis, the intensity of potential impacts on the SBPA from a mitigated marine oil spill would be **Medium**. This leads to a magnitude rating of **Large** and a consequence/severity rating of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall residual risk to the SBPA from a mitigated marine oil spill would be maintained as **Moderate** (see Table 9.5-2).

9.5.2. Special Status Species

For the purposes of this assessment, special status species are defined as those that are listed on the International Union for Conservation of Nature (IUCN) Red List as Near Threatened (NT), Vulnerable (VU), Endangered (EN), or Critically Endangered (CR) on the IUCN Red List Version 2021.1 (IUCN 2021) that are known or expected to occur in the Project AOI (see Section 7.1.2, Existing Conditions—Protected Areas and Special Status Species, and Appendix J, IUCN-Listed Coastal and Marine Species Known From Guyana with Red List Status Classified as Data Deficient).

There are 84 coastal and marine species known or expected to occur in the Project AOI that are listed on the IUCN Red List as NT or higher (i.e., NT, VU, EN, or CR), including 62 fish, 11 birds, 4 marine turtles, 1 terrestrial turtle, and 6 mammals (2 marine mammal and 4 coastal/riverine mammal species). The vast majority of these species are fish, including highly migratory species such as tunas and sharks, bentho-pelagic species including certain groupers, and demersal species including species of skates and rays. As noted in Section 8.1.2, Existing Conditions—Socioeconomic Conditions, many of these fish species are also targeted by the Guyanese commercial fishing industry, which can lead to cumulative effects on these species (see Chapter 10, Cumulative Impact Assessment).

Table 9.5-1 summarizes the IUCN Red List ranking and species type for the 84 marine and coastal species known or expected to occur in the Project AOI that are IUCN Red List ranked NT or higher.

Table 9.5-1: Summary of IUCN Red List Rankings for Special Status Species Known or Expected to Occur in the Project AOI

IUCN Red List Ranking [a]	Taxonomic Groups	Number of Species
CR	1 marine turtle 11 fish	12
EN	1 marine turtle 12 fish 1 seabird 1 coastal/riverine mammal	15
VU	2 marine turtles 1 terrestrial turtle 23 fish 4 coastal birds 1 seabird 1 marine mammal 1 coastal/riverine mammal	33
NT	16 fish 5 coastal birds 1 marine mammal 2 coastal/riverine mammal	24
Total		84

[a] The definitions for each IUCN Ranking are described in Table 7.1-3.

As discussed above, the potential risks of unplanned events on special status marine mammals, riverine mammals, and marine turtles are assessed in Section 9.9, Marine Mammals, Section 9.10, Riverine Mammals, and Section 9.11, Marine Turtles. Accordingly, this section focuses on the impacts of unplanned events on the special status marine fish and bird species.

9.5.2.1. Marine Oil Spill

Special Status Fish

Oil spill modeling indicates that the swept area for a mitigated and unmitigated marine oil spill would occur in Guyana's Exclusive Economic Zone (EEZ) off Regions 1 through 6 under all scenarios. The extent of the oil's predicted effect on the continental shelf[13] changes seasonally, with the highest probability of oil reaching the coast (and therefore a larger portion of the continental shelf) in winter. The implication of these model results is that pelagic, open-ocean fish species would have the highest potential for exposure to oil as the result of a loss-of-well-control event under all scenarios, but that under certain conditions shallow water and continental shelf species could be exposed as well.

Potential impacts on marine species from a marine oil spill are related to water column concentrations of, and the duration of exposure to, dissolved hydrocarbons (primarily PAHs). Hydrocarbon contamination in the water column changes rapidly in space and time, such that potentially harmful exposure levels are typically brief (i.e., measured in hours), except in the case of an ongoing release such as a loss-of-well-control event. Exposure to microscopic oil droplets may impact aquatic biota (especially for filter feeders) either mechanically or as a

[13] The relatively shallow area of seabed extending from the coast to the edge of the continental slope

conduit for exposure to semi-soluble hydrocarbons that might be taken up in the gills or digestive tract via dissolution from the micro-droplets. The early life stages of marine and river fish can absorb PAHs (generally the 2-ring aromatic compounds) directly from the water. These compounds are metabolized when the fish enters clean water, but depending on the duration of the exposure as well as other environmental factors, PAHs at low concentration levels can result in mortality, malformed structures, circulatory failure, and stunted development (Yuewen and Adzigbli 2018).

Using the definitions presented in Table 7.8-4, the intensity of potential impacts of an unmitigated marine oil spill on special status marine fish is considered **High**. The geographic extent of an unmitigated loss-of-well-control event could encompass portions of the **Indirect AOI**. On the basis that impacts on marine fish from an unmitigated loss-of-well-control event would persist as long as the spill remained unmitigated, the frequency is considered to be **Continuous**. Even without mitigation, marine fish would gradually recover to some extent—depending on the degree of oil exposure—but impacts could still persist beyond a year, yielding a **Long-term** duration. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Large**.

The listing status of special status fishes within the Indirect AOI ranges from NT to CR. Applying the sensitivity ratings from Section 7.1.3.2, Special Status Species, yields a sensitivity rating of **High** for CR and EN species and **Medium** for all other special status species. Deterministic oil spill modeling predicts that both mitigated and unmitigated oil spills would both reach Region 1 of the Guyana coast in the winter months under the Maximum WCD modeling scenario. The CR- and EN-status fishes listed in Section 7.1.2.2, Special Status Species, occur in coastal and offshore habitats and would be exposed to the effects of such a spill in offshore and coastal locations. Therefore, applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **High** for all special status fish species. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the pre-mitigation risk to special status fish is considered **Moderate**.

Implementation of the OSRP would reduce the number of CR-, EN-, VU-, and NT-listed fish species that could encounter oil and the area within which those encounters could occur, but all four of these categories include several coastal demersal, coastal pelagic, and offshore pelagic species that could encounter oil even under a mitigated scenario. If applied, dispersants will increase the concentrations of oil entrained in the upper portions of the water column and thus pelagic species' exposure to near-surface entrained oil. The NEBA process would optimize use of dispersant such that the benefits would be expected to outweigh the negative effects of increased concentrations of emulsified or entrained oil near the surface. Accordingly, the intensity of such an impact would be reduced to **Low**, which would reduce the residual impact magnitude to **Small** and lower the residual consequence/severity of marine oil spill-related impacts on special status fishes to **Medium**. In combination with a likelihood of **Unlikely**, the residual risk rating associated with marine oil spill-related impacts on these fishes would be **Minor**.

Special Status Birds

The impacts of a marine oil spill on birds are described in Section 9.8, Seabirds, and Section 9.7, Coastal Wildlife. There are eleven special status bird species that could be impacted by a marine oil spill: two marine species (Black-capped Petrel [*Pterodroma hasitata*; EN] and Leach's Storm-Petrel [*Oceanodroma leucorhoa*; VU]) and nine coastal species (Agami Heron [*Agamia agami*; VU], Rufous Crab Hawk [*Buteogallus aequinoctialis*; NT], Red Knot [*Calidris canutus*; NT], Semipalmated Sandpiper [*Calidris pusilla*; NT], Bicolored Conebill [*Conirostrum bicolor*; NT], Harpy Eagle [*Harpia harpyja*; NT], Ruddy Pidgeon [*Patagioenas subvinacea*; VU], White-bellied Piculet [*Picumnus spilogaster*; VU], and Red-billed Toucan [*Ramphastos tucanus*; VU]).

Based on the potential impacts on birds from an unmitigated marine oil spill described in Section 9.8, Seabirds, and Section 9.7, Coastal Wildlife (excluding transboundary effects which are discussed in Section 9.24, Transboundary Impacts), the intensity of impacts on birds are considered to range from **Medium** (for non-breeding seabirds) to **High** (for breeding seabirds).

The geographic extent of an unmitigated loss-of-well-control event would include portions of the **Indirect AOI**. On the basis that impacts from a loss-of-well-control event would persist as long as the spill remains unmitigated, the frequency is considered to be **Continuous**. Assuming no mitigation, the effects would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Large** for both breeding and non-breeding special status birds.

Applying the sensitivity ratings from Section 7.1.3.2, Special Status Species, yields a sensitivity rating of **High** for Black-capped Petrel and **Medium** for Leach's Storm-Petrel, Agami Heron, Rufous Crab Hawk, Red Knot, Semipalmated Sandpiper, Bicolored Conebill, Harpy Eagle, Ruddy Pidgeon, White-bellied Piculet, and Red-billed Toucan.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the pre-mitigation risk to special status birds is considered **Moderate**. Effective implementation of the OSRP would reduce this risk to **Minor** by limiting the geographic extent of the oil spill, the duration over which the spill would be present on the water surface, and the number of individual birds potentially impacted.

In the case of Leach's Storm-Petrel, however, data from EEPGL-commissioned marine bird surveys conducted in the Stabroek Block since 2017 (see Section 7.4, Seabirds) indicate the offshore PDA is a migratory corridor for a relatively large number of this species. Accordingly, the residual risk rating for marine oil spills as they relate to Leach's Storm-Petrel is maintained at **Moderate** for a spill occurring during the fall or spring migratory period. Of the nine special status coastal bird species known to occur in Guyana, eight were documented during the EEPGL-commissioned coastal bird surveys along the Guyana coast from 2017 through 2019 (see Section 7.3.2.2, Coastal Birds, for a detailed description of these surveys). As described in Section 9.7.2, Marine Oil Spill, coastal birds would be susceptible to a marine oil spill that

impacts the shoreline during foraging, preening, and nesting. Further, breeding can occur at virtually any time of the year depending on availability of food resources, but peak activity typically occurs from October through February (Zima and Francisco 2016), overlapping the winter season in which oil spill modeling indicated the strongest probability of reaching the shore. Considering the potential for a marine oil spill to reach the Guyanese coast in Regions 1 and 2, coastal bird species (particularly those inhabiting mangroves and beaches, would also maintain a residual risk rating of **Moderate**. In contrast, Black-capped Petrel is expected to occur in the PDA very rarely and only during the non-breeding season. In consideration of the extremely low likelihood that this species would be present in the AOI in the unlikely event of an oil spill, combined with implementation of the OSRP, the residual risk is maintained at **Minor** for this species.

9.5.2.2. Coastal Fuel Spill

Special Status Fish

None of the special status fish species listed in Table 7.1-4 have been documented in the Demerara River. A few of these species including bull shark (*Carcharhinus leucas*), daggernose shark (*Isogomphodon oxyrhynchus*), tarpon (*Megalops atlanticus*), and largetooth sawfish (*Pristis pristis*), and several of the skates, rays, and snappers are known to inhabit estuaries and could infrequently enter the lower Demerara River as transients, but are expected to occur only rarely in the area that could be affected by a coastal fuel spill. Largetooth sawfish and daggernose shark are both listed as CR, tarpon is listed as VU, and bull shark is listed as NT. Using the definitions presented in Table 7.8-4 and in light of the marginal value of the Demerara River as habitat for special status fish species, the intensity of potential impacts of an unmitigated coastal fuel spill on special status marine fish is considered **Low**.

The geographic extent of a coastal fuel spill would include the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly over time as the oil spill weathers) and because the impacts of an unmitigated coastal fuel spill could—depending on volume of release—continue over several weeks, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**. Using the definitions in Tables 7.1-6 and 7.1-8 in Section 7.1, Protected Areas and Special Status Species, the sensitivity of special status fish species that could potentially be impacted by a coastal fuel spill is considered **High** to **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to an initial consequence/severity rating of **Medium** to **Low**. In combination with a likelihood rating of **Unlikely** for a coastal fuel spill, the pre-mitigation risk to special status fish from a coastal fuel spill is considered **Minor** for all special status fish species.

Coastal fuel spills would be quickly controlled and contained because of the relatively small volume of the spill and access to spill control equipment at the shorebases. Accordingly, implementation of the OSRP would reduce the residual intensity to **Negligible**, which would reduce the residual magnitude to **Negligible** as well. The residual consequence/severity rating

would decrease to **Low** for all special status marine fish species. Combined with a likelihood of a coastal fuel spill occurring of **Unlikely**, the residual risk rating associated with coastal fuel spill-related impacts would be **Minor** for all special status marine fish species.

Special Status Birds

An unmitigated coastal fuel spill that reaches a Guyana shoreline would likely only happen near the shorebases to be used by the Project, which are located near the mouth of the Demerara River. Nine special status species birds inhabiting coastal areas could be affected by a coastal fuel spill in the lower Demerara River including Agami Heron, Rufous Crab Hawk, Red Knot, Harpy Eagle, Ruddy Pidgeon, Red-billed Toucan, Semipalmated Sandpiper, Bicolored Conebill, and White-bellied Piculet. The Red Knot, Harpy Eagle, Semipalmated Sandpiper, Rufous Crab Hawk, and Bicolored Conebill are all listed as NT. The Red-billed Toucan and White-bellied Piculet are listed as VU.

Despite the degraded and urbanized nature of coastal habitat in the area that could potentially be impacted by a coastal fuel spill, the mangroves lining the west bank of the lower Demerara River and the adjacent coastline support populations of nesting, foraging, and roosting coastal birds, including the nine special status species. Even though the area of impact from a coastal spill would likely be limited, the presence of nine special status birds in this area that live or forage in the water or adjacent habitats makes them vulnerable to direct or indirect exposure to oil from a coastal fuel spill. This exposure could cause similar injury, mortality, and/or behavioral changes in special status birds in and around the affected area to that described above for a marine oil spill, although to a much lower degree because of the limited geographic extent and duration of a coastal fuel spill. The impacts would be greatest if the spill occurred during the nesting period when the adults have eggs and chicks in their nests or during the post-nesting season when juvenile birds stay in close vicinity to their nests and surrounding foraging habitats. As such, the intensity of potential impacts on the nine special status species birds from an unmitigated coastal fuel spill is considered **Medium**. The geographic extent of a coastal fuel spill would include the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spill weathered), and because the impacts of an unmitigated coastal fuel spill could—depending on volume of release—continue over several weeks, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Using the definitions in Table 7.1-6, the sensitivity of special status birds in the area that could potentially be impacted by a coastal fuel spill is considered **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Medium**.

In combination with a likelihood rating of **Unlikely** for a coastal fuel spill, the overall pre-mitigation risk to special status birds from an unmitigated coastal fuel spill would be **Minor**.

Coastal spills would be quickly controlled and contained because of the relatively small volume of the spill and the ready access to spill-control equipment. These impacts would generally be

temporary, limited in area and volume of oil released, and readily mitigated, with rapid habitat recovery expected. Accordingly, with implementation of the OSRP and assuming a low-volume spill, the intensity of potential impacts on the special status birds from a mitigated coastal fuel spill would likely be reduced to a **Negligible** level. This leads to a magnitude rating of **Negligible**, and a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for a coastal fuel spill, the overall residual risk to special status birds from an unmitigated coastal fuel spill would be **Minor** (see Table 9.5-2).

9.5.2.3. Discharge of Untreated Wastewater from the FPSO

Special status marine fish and seabirds would be impacted similarly by a discharge of untreated wastewater from the FPSO. The impacts of a discharge of untreated wastewater from the FPSO on non-special status marine fish and seabirds are discussed in Section 9.12, Marine Fish, and Section 9.8, Seabirds. The magnitude of the impacts of such a discharge to non-special status marine fish and seabirds was rated as **Negligible** and, thus when combined with **Low** sensitivity to this impact, the associated pre-mitigation and residual risk ratings for non-special status marine fish and seabirds were **Minor** (see Sections 9.12.5 and 9.8.4, respectively).

A discharge of untreated wastewater from the FPSO would only occur under an equipment failure scenario and involve release of untreated wastewater directly overboard through an outfall. Such a discharge would have localized impacts on water quality, but conditions that could cause such a release would generally be rectified within a short period of time. The primary constituents in wastewater include solids and biodegradable organics (usually measured in terms of biochemical oxygen demand), carbon, nutrients (primarily nitrogen and phosphorous), and pathogens such as coliform. The affected area of ocean would be somewhat larger than the mixing zone associated with normal operations, but not so large that the event would be regionally significant. As described in Section 9.1.11, Discharge of Untreated Wastewater from the FPSO, modeling results show that a temporary release of untreated wastewater would result in a plume of limited extent and that constituent concentrations would never exceed the end-of-pipe levels recommended by the IMO's 2012 *Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants* (IMO 2012).

Special status fish and birds swimming on or at the water surface could come into dermal contact with the wastewater plume or an individual could ingest a small amount of wastewater while foraging. The constituents and concentration of the wastewater plume are not expected to expose special status fish and birds to toxic effects (injury or mortality) and no effects from contact of the wastewater with a special status fish and seabirds' skin would be expected.

The geographic extent of a discharge of untreated wastewater from the FPSO would be limited to the Direct AOI. Using the definitions established for assessment of potential impact on special status fish and birds from planned Project activities, the intensity of potential impacts of a discharge of untreated wastewater from the FPSO is considered **Negligible**. The frequency of a discharge of untreated wastewater from the FPSO would be **Episodic** because it would occur infrequently (if ever). The duration of this impact would be **Short-term**, as it would assimilate

into the ocean quickly and not persist at the water surface where special status fish and birds swim or forage. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible**.

Using the definitions established for assessment of potential impact on special status fish and birds from planned Project activities, the 21 special status pelagic marine fish species and the two seabird species that could be exposed to this impact would have sensitivity ratings ranging from **Medium** to **High**, depending on the species' listing status. Despite the higher sensitivity ratings for these special status species, the effects of a discharge of untreated wastewater from the FPSO would not be any greater than that described for non-special status species because exposure to this impact would not be expected to cause injury or mortality of individuals. As such, the elevated conservation status of the special status species would not increase the intensity or magnitude of this impact on special status species.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. Multiple redundancies in the FPSO's wastewater management system would have to fail simultaneously for untreated wastewater to be released to the environment, so such an event is considered **Unlikely**. These factors yield a pre-mitigation risk rating to special status fish and birds from a discharge of untreated wastewater from the FPSO of **Minor**.

Response actions would focus on identifying and rectifying the condition that caused the release rather than recovery of discharged material, and the residual risk would be **Minor** (see Table 9.5-2)

9.5.2.4. Collision of a Project Vessel or Helicopter with Seabirds

The potential impacts of collision of a Project vessel or helicopter with seabirds are discussed in Section 9.8, Seabirds. The magnitude ratings for impacts from both vessel collision and helicopter collision to non-special status seabirds were **Small** (see Sections 9.8.5 and 9.8.6 and Table 9.8-1). The two special status seabirds that could be impacted by collision with a Project vessel or helicopter are Black-capped Petrel (EN) and Leach's Storm-Petrel (VU). The conservation status (IUCN rating) of these species yields sensitivity ratings of **High** and **Medium**, respectively. These sensitivity ratings, coupled with the magnitude rating of **Small** and likelihood rating of **Unlikely** for collision of a Project vessel or helicopter with seabirds as described in Section 9.8, Seabirds, yield a pre-mitigation risk rating of **Minor** for both species and both types of impacts. Aside from the embedded controls of vessel captains being trained to recognize rafting seabirds and avoid them if possible, and pilot avoidance of flying seabirds, which is a standard safety protocol, there are no mitigation measures that can be applied to further reduce this potential impact. As such, the residual risk to special status seabirds from these impacts would remain **Minor** (see Table 9.5-2).

9.5.2.5. Seabird Collision with FPSO Flare Tower, Flame, or Radiant Heat Plume

The potential impacts of a seabird collision with the FPSO flare tower, flame, or radiant heat plume are discussed in Section 9.8, Seabirds. The magnitude rating for impacts of non-special

status seabirds colliding with the FPSO flare tower, flame, or radiant heat plume is **Negligible** (see Section 9.8.3 and Table 9.8-1). The two special status seabirds that could be impacted by collision with the FPSO flare tower, flame, or radiant heat plume are Black-capped Petrel (EN) and Leach's Storm-Petrel (VU). The conservation status (IUCN rating) of these species yields sensitivity ratings of **High** and **Medium**, respectively. These sensitivity ratings, coupled with the magnitude rating of **Negligible** and likelihood rating of **Possible** as described in Section 9.8, Seabirds, yield a pre-mitigation risk rating of **Minor** for both species. There are no mitigation measures that can be applied to further reduce this potential impact. As such, the residual risk to special status seabirds from collision with the FPSO flare tower, flame, or radiant heat plume would remain **Minor** (see Table 9.5-2).

Table 9.5-2: Risk Ratings for Unplanned Event Impacts on Protected Areas and Special Status Species

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Protected Areas (SBPA)	Unlikely	High	Moderate	Implement OSRP	Moderate
Marine Oil Spill	CR and EN Fish Species	Unlikely	High	Moderate	Implement OSRP	Minor
	VU and NT Fish Species	Unlikely	Medium	Moderate	Implement OSRP	Minor
	EN Black Capped Petrel (*Pterodroma hasitata*)	Unlikely	High	Moderate	Implement OSRP	Minor
	VU Leach's Storm-Petrel (*Oceanodroma leucorhoa*)	Unlikely	High	Moderate	Implement OSRP	Moderate
	VU and NT Coastal Bird Species	Unlikely	High	Moderate	Implement OSRP	Moderate
Coastal Fuel Spill	CR and EN Fish Species	Unlikely	High	Moderate	Implement OSRP	Minor
	VU and NT Fish Species	Unlikely	Medium	Minor	Implement OSRP	Minor
	VU and NT Coastal Bird Species	Unlikely	Low	Moderate	Implement OSRP	Minor
Discharge of Untreated Wastewater from the FPSO	Special Status Marine Fish and Seabirds	Unlikely	Low	Minor	None	Minor
Helicopter strike	EN Black-capped Petrel	Unlikely	Low	Minor	None	Minor

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
	VU Leach's Storm-Petrel	Unlikely	Low	Minor	None	Minor
Vessel strike	EN Black-capped Petrel	Unlikely	Low	Minor	None	Minor
	VU Leach's Storm-Petrel	Unlikely	Low	Minor	None	Minor
Collision with flare tower, flame, or radiant heat plume	EN Black-capped Petrel	Possible	Low	Minor	None	Minor
	VU Leach's Storm-Petrel	Possible	Low	Minor	None	Minor

9.6. COASTAL HABITATS

As indicated in Table 9.1-6, the unplanned events with the potential to result in measurable impacts on coastal habitats would be a marine oil spill and a coastal fuel spill.

9.6.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Definitions for intensity of impact and sensitivity of receptor were not provided in the assessment of potential impacts on coastal habitats from planned Project activities because there are no potential impacts on coastal habitats from planned Project activities. As the methodology for determining a rating for risks to coastal habitats from an unplanned event involves consideration of the intensity of the impacts (assuming the unplanned event was to occur) and the sensitivity of the receptor(s), they are therefore provided in this section. Table 9.6-1 includes the definitions for the intensity of potential impacts on coastal habitats and Table 9.6-2 includes the definitions for the sensitivity of coastal habitats.

Table 9.6-1: Definitions for Intensity Ratings for Potential Impacts on Coastal Habitats

Criterion	Definition
Intensity	Negligible: No changes to habitat functions and values.
	Low: Minimal changes to habitat functions and values, limited to a localized area.
	Medium: Changes to habitat functions and values over a moderately sized area.
	High: Substantial habitat degradation leading to widespread reduction in habitat functions and values.

Table 9.6-2: Definitions for Sensitivity Ratings for Potential Impacts on Coastal Habitats

Criterion	Definition
Sensitivity	Low: Affected habitat(s) does not have elevated susceptibility to Project-related impacts, and can recover quickly from Project-related impacts.
	Medium: Affected habitat(s) has an elevated susceptibility to Project-related impacts, and/or cannot readily recover from Project-related impacts, but the impacted area represents a small fraction of the overall coastal habitat assemblage.

Criterion	Definition
	High: Affected habitat(s) has an elevated susceptibility to Project-related impacts, and/or cannot readily recover from Project-related impacts, and the impacted area represents a substantial fraction of the overall coastal habitat assemblage.

9.6.2. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Stochastic modeling for both scenarios indicates a 5 to 40 percent probability of an unmitigated spill reaching a Guyana shoreline in Region 1, and a 5 to 10 percent probability of an unmitigated spill reaching Region 2 depending on wind and current conditions at the time of the spill. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain offshore of Guyana for the Most Credible WCD scenario and for the Maximum WCD (Jun–Nov) scenario. Deterministic modeling predicts impact across most of the Region 1 coast for the (Dec–May) Maximum WCD scenario. Modeling of a mitigated Maximum WCD scenario indicates that mitigation would reduce the length of shoreline impacted compared to an unmitigated scenario, but most of the Region 1 shoreline would be affected. The deterministic modeling analysis does not predict shoreline impacts in Guyana outside of Region 1 for either the Most Credible WCD or Maximum WCD scenarios, regardless of season or the effects of mitigation. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

The shoreline where stochastic modeling indicates a 5 to 40 percent probability of the oil contacting the coast is in Region 1, and a 5 to 10 percent probability of the oil reaching Region 2. Stochastic modeling indicates that the minimum time for oil to reach the Guyana shoreline in these areas would be between 5 and 10 days, depending on spill scenario and season. The shoreline in Region 1 is dominated by mangrove forest of high or exceptional quality (see Section 7.2, Coastal Habitats). Mangroves also occur in Region 2; however, the largest remaining stands in Guyana occur in the SBPA in Region 1, and are present along this entire section of Guyana's coast, just inland from the sand beach. Other coastal habitats that are particularly susceptible to oil spills (e.g., coral reefs, seagrass beds) are not found along the Guyana coast.

Mangroves are important providers of a number of ecological services upon which fish, wildlife, and humans rely. Mangroves provide valuable habitat for crabs and important nursery areas for fish and shrimp, and provide coastal protection from wave action. Mangroves are typically found along the margins of shorelines at the saltwater interface. Due to this physical location, mangroves are vulnerable to exposure during oil spills. Mangroves are considered sensitive to heavy contamination by oil for several reasons (ITOPF 2014):

- Mangroves rely on oxygen supplied through small pores (lenticels) on their aerial roots. Smothering of the aerial roots by high loadings of heavy hydrocarbons can block this important oxygen pathway.
- The toxic component of oil can interfere with mangroves' systems for maintaining salt balance, impacting their ability to tolerate salt water; this risk is greatest for light oil types or

unweathered oils that still have a high proportion of aromatic compounds (Yellowtail oil is considered a medium oil type that would also be weathered by the time it contacted a Region 1 coastline).

- Oil can become trapped in mangrove sediments, where it may remain in a relatively unweathered state and gradually remobilize over a long period, causing repeated “pulses” of exposure.
- Mangrove habitat recovery after oil exposure often takes 10 years or longer, especially where the shoreline protection services of the mangroves have been compromised by manmade activity and an increase in erosion (Hayashi et al. 2019).

Almost all of the mangroves that line the shoreline in Region 1 are mature, and most have experienced significant erosion in recent years (Toorman et al. 2018). A few mangroves, particularly near Iron Punt, have disappeared completely in recent years. Recent sediment accretion has promoted expansion of both young and mature mangroves in a few small areas between Iron Punt and the mouth of the Pomeroon River. In addition, in two areas farther northwest between Iron Punt and Kamwatta Beach, accretion has promoted expansion of mature mangroves. Despite these isolated areas of expansion, mangroves are currently in decline in areas where stochastic and deterministic modeling shows potential for shoreline oiling from a mitigated or unmitigated marine oil spill.

Using the definitions above, the intensity of potential impacts of an unmitigated marine oil spill on coastal habitats (mangroves) is considered **High**. The geographic extent of an unmitigated loss-of-well-control event would encompass portions of the **Indirect AOI**. On the basis that impacts on coastal habitat from an unmitigated loss-of-well-control event would persist as long as the spill remained unmitigated, the frequency is considered to be **Continuous**. Even without mitigation, coastal habitat would gradually recover to some extent—depending on the degree of oiling—but impacts could still persist beyond a year, yielding a **Long-term** duration. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**.

Using the definitions presented above in Table 9.6-2, the sensitivity of coastal habitats in the areas with the potential to be affected by a marine oil spill is considered **High**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the pre-mitigation risk to coastal habitats is considered **Moderate**.

Mitigation for a marine oil spill would involve implementation of the OSRP. Deterministic modeling predicts that a mitigated marine oil spill would reach Region 1 of the Guyana shoreline in the winter months. On this basis, the intensity of potential impacts on coastal habitats in Guyana from a mitigated marine oil spill would be **High**. This leads to a magnitude rating of **Large** and a consequence/severity rating of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall residual risk to coastal habitats from a mitigated marine oil spill would be maintained as **Moderate** (see Table 9.6-3).

9.6.3. Coastal Fuel Spill

An unmitigated coastal fuel spill that reaches a Guyana shoreline would likely only happen near the shorebases that would be used by the Project, which are located near the mouth of the Demerara River. As with a marine oil spill, the primary coastal habitat that could be affected by a coastal fuel spill in the lower Demerara River is mangrove. Other coastal habitat types in this area include vegetated low banks and exposed, solid manmade structures, which are common in urbanized environments in Guyana. Mature, growing mangroves that are characterized as Critical Sensitivity in the coastal sensitivity mapping, despite being somewhat degraded by human activity (see Appendix O, Coastal Sensitivity Maps), line the west bank of the lower river and the adjacent coastline, while the east bank of the river is primarily characterized by exposed, solid manmade structures with some vegetated low bank habitats interspersed throughout. The mangroves and vegetated low banks would be susceptible to exposure to a fuel spill.

Considering the degraded and urbanized nature of coastal habitat in the area that could potentially be impacted by a coastal fuel spill and the likely limited area of impact from a coastal spill, the intensity of potential impacts on coastal habitats from an unmitigated coastal fuel spill would likely be **Low**. The geographic extent of an unmitigated coastal fuel spill would likely be limited to the **Indirect AOI**. On the basis that impacts on coastal habitats would persist for as long as the spill remains unmitigated (although the nature of the impacts would change over time as the oil spill weathers), and because the impacts of an unmitigated coastal fuel spill could—depending on the volume of material released—continue for several weeks, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**.

Using the definitions above, the sensitivity of coastal habitat in the area that could be impacted by a coastal fuel spill is considered **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**.

In combination with a likelihood rating of **Unlikely** for a coastal fuel spill, the overall pre-mitigation risk to coastal habitat from an unmitigated coastal fuel spill would be **Minor**.

Coastal spills would be quickly controlled and contained because of the relatively small volume of the spill and the ready access to spill control equipment available at shorebases. These impacts would generally be temporary, limited in area and volume of oil released, and readily mitigated, with rapid habitat recovery expected. Accordingly, with implementation of the OSRP and assuming a low volume spill, the intensity of potential impacts on coastal habitat from a mitigated coastal fuel spill would likely be reduced to a **Negligible** level. This leads to a magnitude rating of **Negligible**, and a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for a coastal fuel spill, the overall residual risk to coastal habitats from an unmitigated coastal fuel spill would be **Minor** (see Table 9.6-3).

Table 9.6-3: Risk Ratings for Unplanned Event Impacts on Coastal Habitats

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Coastal Habitats	Unlikely	High	Moderate	Implement OSRP	Moderate
Coastal Fuel Spill	Coastal Habitats	Unlikely	Low	Minor	Implement OSRP	Minor

9.7. COASTAL WILDLIFE

As indicated in Table 9.1-6, the unplanned events with the potential to result in measurable impacts on coastal wildlife include a marine oil spill and a coastal fuel spill.

9.7.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Definitions for intensity of impact and sensitivity of receptor were not provided in the assessment of potential impacts on coastal wildlife from planned Project activities because, as described in Section 7.3.3, Impact Assessment—Coastal Wildlife, there are no potential impacts on coastal wildlife from planned Project activities. The methodology for determining a rating for risks to coastal wildlife from an unplanned event involves consideration of the intensity of the impacts (assuming the unplanned event was to occur) and the sensitivity of the receptor(s); therefore, they are provided in this section. Table 9.7-1 includes the definitions for the intensity of potential impacts from unplanned events on coastal wildlife, and Table 9.7-2 includes the definitions for the sensitivity of coastal wildlife to impacts from unplanned events.

Table 9.7-1: Definitions for Intensity Ratings for Potential Impacts on Coastal Wildlife

Criterion	Definition
Intensity	Negligible: No discernible change in coastal wildlife behavior or presence in the impacted area.
	Low: Minor behavioral changes exhibited in coastal wildlife or occasional injury or mortality of few individuals that would not measurably impact habitat use, regional population status, or viability of coastal wildlife populations.
	Medium: Regularly observed changes in behavior of coastal wildlife and/or injury and mortality of individuals, but not such that this would affect the long-term viability of regional coastal wildlife populations.
	High: Significant changes in behavior of coastal wildlife or significant injury or mortality that could affect the long-term viability of coastal wildlife populations.

Table 9.7-2: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Coastal Wildlife

Criterion	Definition
Sensitivity	Low: No coastal wildlife species known or expected to occur in the PDA possess unique susceptibilities to Project-related impacts. Impacts, should they occur, would be on individual animals.
	Medium: One or a limited number of coastal wildlife species with elevated susceptibility to Project-related impacts due to prolonged or regular presence in the PDA, and/or one or a limited number of species that exhibit habitat preferences or behaviors that limit their ability to avoid Project-related impacts, but representing a small fraction of the regional or global populations of affected species.
	High: Several coastal wildlife species with elevated susceptibility to Project-related impacts due to prolonged or regular presence in the PDA, and/or several species that exhibit habitat preferences or behaviors that greatly limit their ability to avoid Project-related impacts, representing a substantial fraction of the regional or global populations of affected species.

9.7.2. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Stochastic modeling for both scenarios indicates a 10 to 40 percent probability in Region 1, and a 5 to 10 percent probability of an unmitigated spill reaching Region 2 of the Guyana shoreline depending on wind and current conditions at the time of the spill. Deterministic marine oil spill modeling predicts that a mitigated and an unmitigated oil spill would both reach Region 1 of the Guyana coast in the winter months under the WCD modeling scenario. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

The shoreline where stochastic modeling indicates a 5 to 40 percent probability of the oil contacting the coast in Region 1 and 2 is largely comprised of mangrove forest with high or exceptional quality, which provides habitat for a diversity and abundance of coastal wildlife species, particularly coastal birds and fish (see Section 7.3, Coastal Wildlife). Many coastal wildlife species are dependent on shoreline mangroves and other coastal habitats, which are particularly sensitive to oil spills because of their physical location along the margins of shorelines at the saltwater interface, and their physiological responses to oil exposure, such as reduced oxygen transfer and reduced ability to maintain salt balance (see Section 9.6, Coastal Habitats). Coastal wildlife habitats in Region 1 and 2 are described in Section 7.2.2, Existing Conditions—Coastal Habitats. The coastal plain habitats contain productive and sensitive habitats such as mangroves, sand and mudflats, and tidal marshes. Within Region 2 and 3, the mangrove-mud coast is generally in good condition; however, around Georgetown, mangrove forests have virtually disappeared (Winterwerp et al. 2020). The mangroves, sand beaches, wetlands, and other coastal habitats that line the coast of Region 1 within the SBPA provide some of the highest quality and least disturbed wildlife habitats in Guyana, and the area is characterized by rich bird, fish, herpetofauna, and mammal communities (see Section 7.1, Protected Areas and Special Status Species, Section 7.2, Coastal Habitats, and Section 7.3, Coastal Wildlife). The impacts of unplanned events on marine turtles, marine fish, and riverine

mammals are discussed in Sections 9.10, Riverine Mammals; Section 9.11, Marine Turtles; and Section 9.12, Marine Fish, respectively, so they are not discussed further in this section.

Coastal birds are uniquely suited as an indicator group for impacts on coastal wildlife in general because they would be affected by impacts on a number of other physical and biological receptors in the intertidal zone (e.g., intertidal water quality, intertidal sediments, intertidal benthos). The EEPGL-commissioned coastal bird surveys conducted along the entire Guyana coastline from 2017 through 2020 provides the most extensive and recent data set on the distribution and species composition of any coastal taxonomic group in Guyana. The EEPGL-commissioned coastal bird surveys identified four Important Bird Habitats along the coastline in Region 1: (1) the SBPA, (2) Pomeroon River mouth, (3) the stretch of beach encompassing Kamwatta Beach, Iron Punt Beach, and Luri Beach, and (4) Waini River Mouth (Section 7.3, Coastal Wildlife). These sites were identified as Important Bird Habitats because they support one or more of the following: (1) predictable congregations of migratory shorebirds; (2) concentrations of roosting and/or nesting wading birds; (3) unique habitat that supports large numbers of riverine forest- and mangrove-dependent species; and (4) important nesting sites for regional endemic species of conservation interest. Specifically, the SBPA contains critically important nesting and foraging habitats for over 200 species of waterbirds and land birds, including several special status species. The Kamwatta/Iron Punt/Luri Beach Complex supports hundreds of Flamingos (multiple species) and thousands of other waterbirds for nesting and feeding. The west bank of the mouth of the Waini River contains a pristine mangrove forest that supports large congregations of colonially roosting and nesting wading birds, such as herons, egrets, and ibis. These sites could be affected by shoreline oiling during an unmitigated marine oil spill.

The most significant impact on coastal birds from an unmitigated spill would occur if oil reached the shoreline or nearshore waters in areas near a large colonial waterbird nesting site during or immediately after the breeding period. Breeding seasons for coastal birds vary, but generally are October through February (Zima and Francisco 2016). However, breeding may occur at any time of year in Guyana because optimum breeding conditions in the tropics are more closely related to food availability than to weather conditions. During these periods, hundreds to thousands of colonial waterbirds (e.g., herons, ibis) congregate to nest and feed in nearshore coastal habitats. Waterbirds feed primarily on fish and other aquatic prey, so they would be susceptible to contact and ingestion of oil during preening if they came into contact with oil. This could injure or kill the impacted individual, and oiled adults could transfer oil to their eggs or chicks in the nest, which are highly susceptible to the effects of oil (Da Silva et al. 1997). Such impacts could affect a breeding year for local populations. A similarly high impact on birds would occur if the nearshore or coastal habitats were oiled during spring or fall shorebird migration, when tens of thousands of migratory shorebirds stopover in coastal habitats along Guyana's coastline, including Region 1 and 2, to forage and rest.

The EEPGL-commissioned fish surveys conducted in 2019 and 2020 along the Guyana coastline included surveys of nearshore and estuarine/riverine areas (ERM 2021). Surveys of these areas were conducted in both the wet and dry seasons. Region 2 had the greatest

number of nearshore fish species and the Demerara estuarine/riverine area in Region 2 had the most species in the May to June wet season.

Species in the nearshore and estuarine/riverine areas could be exposed to oil droplets and dissolved oil in the water column and surface slicks or sheens. For species in these coastal habitats, eggs and larvae are affected by the type of oil and the concentrations of hydrocarbons in the water or sediment. Species mortality in nearshore and estuarine/riverine areas is influenced by water temperature, concentration, and exposure duration. In addition to the direct mortality, depending upon the season when an oil spill occurred, young-of-the-year may be lost via habitat disruption. Potential nearshore and estuarine/riverine losses after the oil spill are the loss of the larvae and juveniles, reduced growth, changes in food availability and productivity, and reduced growth rate or loss of reproductive potential (French-McCay 2009).

Given the abundance and diversity of coastal wildlife and coastal wildlife habitats along the shoreline of Region 1 and 2 within the area that could potentially be oiled during an unmitigated oil spill and the definitions provided in Table 9.7-1, the intensity of potential impacts of an unmitigated marine oil spill on coastal wildlife and associated habitats is considered **High**. The geographic extent of an unmitigated loss-of-well-control event would encompass portions of the **Indirect AOI**. On the basis that impacts on coastal wildlife from an unmitigated loss-of-well-control event would persist as long as the spill remained unmitigated, the frequency is considered to be **Continuous**. Even without mitigation, coastal wildlife could gradually recover to some extent—depending on the degree of oiling—but impacts could still persist beyond a year, yielding a **Long-term** duration. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**.

Using the definitions presented in Table 9.7-2, the sensitivity of coastal wildlife in the areas with the potential to be affected by a marine oil spill is considered **Medium**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the pre-mitigation risk to coastal wildlife is considered **Moderate**.

With implementation of the OSRP, deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill would not reach the Guyana shoreline. On this basis, the intensity of potential impacts on coastal wildlife in Guyana from a mitigated marine oil spill would be **Negligible** for terrestrial wildlife (species living on land) and **Low** for coastal birds that regularly undergo long distance offshore foraging trips (up to hundreds of kilometers offshore) and could be exposed to oil in the offshore environment. This leads to a magnitude rating of **Negligible** to **Small**, reducing the consequence/severity rating to **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall residual risk to coastal wildlife from a mitigated marine oil spill would be **Minor** (see Table 9.7-3).

9.7.3. Coastal Fuel Spill

A coastal fuel spill that reaches a Guyana shoreline would likely only happen north of the shorebases the Project would use, which are located near the mouth of the Demerara River. The primary wildlife taxa and habitats that could be affected by a coastal fuel spill north of the Demerara River are birds, fish, and coastal habitats. The impacts of unplanned events on wildlife habitats are discussed in Section 9.6, Coastal Habitats and Section 9.12, Marine Fish, respectively, so they are not discussed further in this section.

Guyana's coastal plain supports large and diverse populations of nesting, foraging, and roosting coastal birds, particularly waterbirds. Many of the species present in this area congregate in large groups for breeding and roosting and so would be particularly vulnerable to exposure from a coastal fuel spill in the Demerara River and/or the Demerara Harbour. Even though the area of impact from a coastal fuel spill would likely be limited, the presence of many birds and other coastal wildlife in this area that live or forage in the water or adjacent habitats creates a high risk of direct or indirect exposure from a coastal fuel spill. This exposure could cause similar injury, mortality, and/or behavioral changes in coastal birds in and around the affected area to that described for a marine oil spill above. As such, the intensity of potential impacts on coastal wildlife, particularly birds, from an unmitigated coastal fuel spill could, depending on the volume of the release, be **High**. The geographic extent of an unmitigated coastal fuel spill would likely be limited to the **Indirect AOI**. On the basis that impacts on coastal wildlife species would persist for as long as the spill remains unmitigated (although they would reduce over time as the spilled fuel weathers), and because the impacts of an unmitigated coastal fuel spill could—depending on the volume of release—continue over several weeks, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Using the definitions in Table 9.7-2, the sensitivity of coastal wildlife, particularly birds, in the area that could potentially be impacted by a coastal fuel spill is considered **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Medium**.

In combination with a likelihood rating of **Unlikely** for a coastal fuel spill, the overall pre-mitigation risk to coastal wildlife from an unmitigated coastal fuel spill would be **Minor**.

Coastal fuel spills would be quickly controlled and contained because of the relatively small volume of the spill and the ready access to spill control equipment. These impacts would generally be temporary, limited in area and volume of oil released, and readily mitigated, with rapid habitat recovery expected. Accordingly, with implementation of the OSRP and assuming a low volume spill, the intensity of potential impacts on coastal wildlife from a mitigated coastal fuel spill would likely be reduced to a **Negligible** level. This leads to a magnitude rating of **Negligible**, and a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for a coastal fuel spill, the overall residual risk to coastal habitats from an unmitigated coastal fuel spill would be **Minor** (see Table 9.7-3).

Table 9.7-3: Risk Ratings for Unplanned Event Impacts on Coastal Wildlife

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Coastal Wildlife	Unlikely	High	Moderate	Implement OSRP	Minor
Coastal Fuel Spill	Coastal Wildlife	Unlikely	Medium	Minor	Implement OSRP	Minor

9.8. SEABIRDS

As indicated in Table 9.1-6, the unplanned events with the potential for measurable impacts on seabirds[14] include a marine oil spill, non-routine flaring on the FPSO, discharge of untreated wastewater from the FPSO, a collision of a Project vessel with rafting seabirds, and a collision of a Project helicopter with seabirds in flight.

9.8.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Tables 7.4-8 and 7.4-9 in Section 7.4, Seabirds, contain the definitions for intensity of impact and sensitivity of receptor, respectively, for potential impacts on seabirds.

9.8.2. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, stochastic oil spill modeling for the Most Credible WCD and Maximum WCD scenarios indicates a 5 to 40 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 1 and a 5 to 10 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 2. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain offshore of Guyana for the Most Credible WCD scenario and for the Maximum WCD (Jun–Nov) scenario. Deterministic modeling predicts impact across the majority of the Region 1 shoreline for the (Dec–May) Maximum WCD scenario. Modeling mitigation under this scenario predicts a reduction in the predicted length of shoreline impact in Region 1, but the predicted length still represents the majority of the Region 1 shoreline. The deterministic modeling analysis does not predict shoreline impacts in Guyana outside of Region 1 for either the Most Credible WCD or Maximum WCD scenarios, regardless of season or the effects of mitigation. The predicted extent of the oil's encroachment into nearshore areas changes seasonally, with the highest probability of oil reaching the coast (and therefore the nearshore environment) in winter. The implication of these model results is that pelagic seabirds would have the highest potential for exposure to oil as the result of a loss-of-well-control event but that under certain conditions nearshore marine birds (a group of seabirds that occurs offshore but most often within nearshore marine environments rather than the open ocean beyond the shelf) could be exposed as well.

In the unlikely event of a marine oil spill, implementation of the OSRP may include use of dispersants for certain types of spill scenarios. While providing a clear benefit for controlling an

[14] In this unplanned events analysis, the term "seabirds" is used to collectively refer to any bird over or on the ocean, regardless of whether the birds' primary habitat is found on land, along the coast, or on the ocean.

oil spill, recent research shows that exposure to high concentrations of dispersants can have immediate adverse impacts on some species of seabirds such as Common Murre (*Uria aalge*) (Whitmer et al. 2018). Whitmer et al. found that at high concentrations, dispersants can have immediate external impacts on affected individuals: murres exposed to both dispersant-treated oil and oil alone experienced an immediate and persistent loss of waterproofing and buoyancy. These effects resolved after cleaning. The same factors that would dilute oil in the open ocean (e.g., water and air temperature, marine currents, wind, wave action) would also act to rapidly dilute a dispersant-oil mixture. Since dilution in the marine environment occurs rapidly (especially in areas with strong current activity such as the PDA), the potential for exposure to high concentrations of dispersants and related acute impacts from dispersant or dispersed oil would be limited in duration and space, and chronic exposure is not expected to be a significant factor in the overall risks posed to seabirds during a marine oil spill event. Accordingly, it is concluded that the use of dispersants in alignment with NEBA, as described in the OSRP, generally does not represent an additional risk to seabirds compared to the effects of exposure to oil alone.

9.8.2.1. At Sea (Non-breeding) Exposure

Seabirds and migratory landbirds occurring in the Stabroek Block are usually flying over the area during migration (or shorter regional dispersals). Seabirds may forage for fish and other marine fauna at or just below the water surface and may rest or sleep for brief periods on the water surface. No nesting or other concentrations of seabirds or migratory landbirds occur in the PDA or the broader Stabroek Block. Seabirds nesting in Venezuela, Trinidad and Tobago, and other islands in the southern Caribbean fly over the Stabroek Block during local dispersal movements or during long offshore foraging trips.

Seabirds spend most of their life at the air-water interface, where floating oil accumulates (surface slick) after an oil spill (Wiens 1996). As such, seabirds are particularly vulnerable to oil because of their distribution and foraging behavior, which is usually associated with the sea surface or just below the water surface in the open ocean (Morandin and O'Hara 2016). Contact with crude oil can cause a variety of immediate and direct impacts on seabirds, such as disrupting feather integrity (water-proofing), thermal insulation, and buoyancy (Troisi et al. 2016, Matcott et al. 2019). Oil on a seabird's feathers can prevent them from diving and flying, which often leads to death because they cannot forage to feed (Troisi et al. 2016). Oil on feathers can also alter seabirds' thermoregulation and the effects can vary between species (Matcott et al. 2019). According to Maggini et al. (2017), even small exposures to crude oil can reduce the integrity of feathers and impair flight performance, causing affected birds to use more energy during flight. Moreover, PAHs (a constituent of oil), if ingested through preening and feeding, can cause tissue and plasma contamination (Troisi et al. 2006).

In summary, an oil spill could pose a risk to seabirds through direct and indirect mechanisms, including the following:

- Loss of insulating and water-repelling properties from oiling of plumage, leading to increased mortality;

- Loss or impairment of flight and buoyancy from oiling of plumage can render birds unable to feed at sea, which can quickly lead to dehydration and starvation;
- Toxic impacts from the ingestion of hydrocarbons during preening, ingestion of contaminated prey, inhalation of fumes, or absorption of hydrocarbons through skin or eggs, leading to increased mortality;
- Habitat degradation at sea and at island or shoreline breeding sites; and
- Mortality of food resources.

Since most oils float, at least initially following a release, seabirds that spend significant time resting or foraging on the water's surface are most at risk from direct exposure. Diving seabirds are considered to have the highest risk of oiling.

Depending on the geographic extent of a spill, seabirds and migratory landbirds may not come into contact with a spill, as they are highly mobile and often fly over the Stabroek Block en route to preferred habitats In the case of seabirds, for these species to avoid an unmitigated marine oil spill, they might need to vacate a large area of the nearshore and offshore environment west of the spill source, depending on season and oceanographic conditions at the time of the spill. A widespread event could interrupt or delay migrations (including shorter regional dispersals) and related life-history events (breeding success, or post-breeding dispersal) during the year of impact (Walter et al. 2014; Morandin and O'Hara 2016), but longer-term impacts on seabird migration, migratory landbirds, and related life-history events are not anticipated (Wiens 1995).

9.8.2.2. Exposure of Breeding Seabirds

For colonially nesting seabird species[15], if a spill occurs during the breeding period and oil reaches a breeding colony or impacts individuals offshore by introducing oil and/or dispersants to the colony, the impacts on seabirds would be more severe compared with spills that are limited to the open ocean and those that occur during the non-breeding season. This is because for most of the year outside the breeding season, seabirds are largely solitary, spending most of their time alone and at sea. But during the breeding season, colonially nesting seabirds typically nest close together on islands or shorelines and forage at higher density in proximity to their nesting sites (but in some cases great distances from the nest sites depending on food availability), making larger numbers of birds and their eggs susceptible to oiling. Reproduction requires a large amount of energy and a bird's demand for food resources can double or triple during the breeding season. Seabird-nesting periods in tropical environments are highly variable and aligned closely with food availability. If an oil spill causes mortality or contamination of the birds' food resources, it can inhibit the birds' ability to successfully mate and produce eggs (Henkel et al. 2012). Eggs and very young birds are particularly sensitive to oil exposure, which typically causes embryonic mortality in eggs or death from exposure in chicks (Finch et al. 2011). Some seabirds lay only one egg at a time, so they have an already low reproductive rate,

[15] Colonially nesting seabird species are seabirds that nest in groups called colonies. Most of the seabird species detected during EEPGL surveys are colonial nesters.

which makes these species more susceptible to adverse impacts from spills that occur in the breeding season because they could lose an entire recruitment year.

No marine Important Bird Areas (IBAs) (e.g., seabird breeding colonies and surrounding foraging areas, non-breeding concentrations, feeding areas for pelagic species) have been designated in Guyana. Several marine IBAs of global or regional importance to seabirds designated in neighboring countries support globally important breeding populations of multiple seabird species, and breeding seabirds from these colonies could occasionally transit through the Stabroek Block during long-distance offshore foraging trips. Potential impacts on these areas from an unmitigated marine oil spill are discussed in Section 9.24, Transboundary Impacts.

Based on the potential impacts on seabirds from an unmitigated marine oil spill (excluding transboundary effects, which are discussed in Section 9.24, Transboundary Impacts), the intensity of impacts on seabirds are considered to range from **Medium** for non-breeding seabirds to **High** for breeding seabirds.

The geographic extent of an unmitigated loss-of-well-control event would include portions of the **Indirect AOI**. On the basis that impacts from a loss-of-well-control event would persist as long as the spill remains unmitigated, the frequency is considered to be **Continuous**. Assuming no mitigation, the effects would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large** for both nesting and non-nesting seabirds.

Based on the sensitivity ratings developed for potential impacts on seabirds from planned activities, a sensitivity rating of **Medium** is assigned for seabirds.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the (pre-mitigation) risk to seabirds is considered **Moderate**. Effective implementation of the OSRP would reduce this risk to **Minor** by limiting the geographic extent of the oil spill, the duration over which the spill would be present on the water surface, and the number of individual birds potentially impacted.

9.8.3. Seabird Collision with FPSO Flare Tower, Flame, or Radiant Heat Plume

A reasonable worst-case estimate for non-routine flaring emissions, while not planned to occur, has been analyzed and is presented in Section 6.1, Air Quality, Climate, and Climate Change. The FPSO will have a flare system, including a pilot flame, for the collection and safe disposition of produced hydrocarbon gases resulting from unplanned, non-routine maintenance or repairs, or emergency shutdown events. The flare tower design includes a protected continuous pilot flame used to ignite the flare. The protected pilot flame would not be accessible to seabirds or migratory landbirds as the pilot flame burners are within a tube. Should flaring occur, it would emanate from a flare tower located on top of the FPSO.

While individual seabirds could be significantly impacted through contact with the FPSO flare tower, its flame, or its radiant heat plume, the likelihood of a seabird colliding with the tower or being present in the heat zone when temporary, non-routine flaring is occurring is extremely low. To date, most of the records from the marine bird surveys conducted on behalf of EEPGL since 2017 have been of solitary birds or small groups. While this does not preclude the possibility of a flock to occur, it is considered relatively rare and any such flocks would likely be small. Even during migration, most individuals are solitary or flying in loose groups (spread out spatially). Accordingly, in the unlikely circumstance that such an event occurred, it would likely only impact a single individual and have no discernable effect on any bird population.

Using the definitions established for assessment of potential impact on seabirds from planned Project activities, the intensity of potential impacts on seabirds from non-routine flaring on the FPSO is considered **Low**. The geographic extent of non-routine flaring on the FPSO would be limited to the **Direct AOI**. The frequency of non-routine flaring would be **Episodic** because it would occur infrequently and at irregular intervals. The duration of non-routine flaring is considered to be **Short-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Negligible**.

Using the definitions established for assessment of potential impact on seabirds from planned Project activities, the sensitivity of seabirds to impacts from non-routine flaring is considered **Low**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. In combination with a likelihood rating of **Possible**, the (pre-mitigation) risk to seabirds from non-routine flaring is considered **Minor**. There are no mitigation measures that can be applied to further reduce this potential impact. As such, the overall residual risk to seabirds from non-routine flaring would be **Minor** (see Table 9.8-1).

9.8.4. Discharge of Untreated Wastewater from the FPSO

A discharge of untreated wastewater from the FPSO would only occur under an equipment failure scenario and would involve release of untreated wastewater directly overboard. Such a discharge would have localized impacts on water quality, but conditions that could cause such a release would generally be rectified within a short period of time. The primary constituents in wastewater include solids and biodegradable organics (usually measured in terms of biochemical oxygen demand), carbon, nutrients (primarily nitrogen and phosphorous), and pathogens such as coliform. The affected area of ocean would be somewhat larger than the mixing zone associated with normal operations, but not so large that the event would be regionally significant. As described in Section 9.1.11, Untreated of Untreated Wastewater from the FPSO, modeling results show that the temporary release of untreated wastewater would result in a plume of limited extent and that constituent concentrations would not be expected to exceed the end-of-pipe levels recommended by the IMO's 2012 *Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants* (IMO 2012).

A seabird foraging in the water or resting on the water surface could come into dermal contact with the wastewater plume or an individual may ingest a small amount of wastewater during foraging or preening. The character (constituents and concentration) of the wastewater plume would not expose seabirds to concentrations resulting in toxic effects (injury or mortality). Due to the low concentrations, contact with wastewater is not expected to have dermal effects on seabirds' skin or feathers.

The geographic extent of a discharge of untreated wastewater from the FPSO would be limited to the **Direct AOI**. Using the definitions established for assessment of potential impact on seabirds from planned Project activities, the intensity of potential impacts of a discharge of untreated wastewater from the FPSO is considered **Negligible**. Despite flying long distances over the open ocean, seabirds would only contact the water intermittently while at sea to drink, feed, or possibly rest (many species rest on land) and not at all while roosting, nesting, and loafing on shore. Although effects on water quality from a discharge of untreated wastewater would be continuous as long as the discharged material was in contact with the water, seabirds' exposure to the discharged material would be **Episodic** because it would only occur when the birds are in direct contact with seawater. The duration of this impact would be **Short-term**, as it would assimilate into the ocean quickly. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Negligible**.

Using the definitions established for assessment of potential impact on seabirds from planned Project activities, the sensitivity of seabirds to impacts from a discharge of untreated wastewater from the FPSO is considered **Low**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. Multiple redundancies in the FPSO's wastewater management system would have to fail simultaneously in order for untreated wastewater to be released to the environment, so such an event is considered **Unlikely**. These factors yield a pre-mitigation risk rating to seabirds from a discharge of untreated wastewater from the FPSO of **Minor**.

Response actions would focus on identifying and rectifying the condition that caused the release rather than recovery of discharged material, and the residual risk would be **Minor** (see Table 9.8-1).

9.8.5. Collision of a Project Vessel with Rafting Seabirds

Rafting seabirds may suffer injury or mortality from collision with vessels transiting to and from the PDA. However, rafters are not likely to be present in large aggregations in the PDA because of the metocean conditions offshore Guyana—namely a strong surface current, which is likely to make the surface waters unsuitable for the large aggregations of species that favor more calm and sheltered conditions. Seabird data collected in the Stabroek Block from 2015 through 2020 did not document any concentrations of rafting seabirds in the area. No more than three individuals were observed at a time in offshore areas beyond 100 kilometers (approximately 62 miles) from shore. Should rafting seabirds be present in the PDA, individuals could be

susceptible to vessel strike and related injury or mortality. However, large seabird rafts are easily detectible by oncoming vessels, and these vessels could maneuver to avoid them if the birds do not move out of the vessels' path. Observations recorded during EEPGL-commissioned marine bird surveys from 2017 through 2020 document that birds present on the water surface move in response to oncoming vessels. In the unlikely event such an interaction would occur, effects would vary with the abundance of seabirds present.

Using the definitions established for assessment of potential impact on seabirds from planned Project activities, the intensity of potential impacts on seabirds from collision of a Project vessel with rafting seabirds is considered **Low**. On the basis that vessel traffic will be a consistent presence in the **Direct AOI**, the frequency and duration are considered to be **Continuous** and **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**.

Using the definitions established for assessment of potential impact on seabirds from planned Project activities, the sensitivity of seabirds to impacts from collision of a Project vessel with rafting seabirds is considered **Low**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. As an embedded control, vessel captains are trained to recognize rafting seabirds and avoid them if possible. This, combined with the expected rare occurrence of rafting seabirds in the PDA, yields a likelihood rating of **Unlikely**; the pre-mitigation risk to seabirds from collision of a Project vessel with rafting seabirds is considered **Minor**. There are no additional mitigation measures that would further reduce this potential impact. As such, the residual risk to seabirds from this impact would remain **Minor** (see Table 9.8-1).

9.8.6. Collision of a Project Helicopter with Seabirds in Flight

Helicopters will be used as a form of transit to/from the Guyana shorebases and offshore vessels, and could adversely impact seabirds through helicopter strikes of individuals flying near helicopters transiting around or in route to/from the drill ships, the FPSO, and major installation vessels. Logistical support will be optimized and shared among Liza Phase 1, Liza Phase 2, Payara, and Yellowtail. During combined development drilling and FPSO/SURF installation, helicopter flights for the Project will be on the order of approximately 20 to 25 round-trip flights per week (assuming up to three drill ships drilling Yellowtail development wells concurrently). This same frequency of helicopter flights will continue during combined production operations and continued development-drilling activities (assuming up to three drill ships drilling Yellowtail development wells concurrently). Following completion of development well drilling, helicopter trips will reduce to an estimated five to seven round-trip flights per week during production operations

Considering this estimated quantity of flights, and based on the relatively low seabird density in the Project AOI during most of the year, the number of helicopter-bird interactions is expected to be very low. In the unlikely event such an interaction would occur, it would likely be limited to a single individual.

Using the definitions established for assessment of potential impact on seabirds from planned Project activities, the intensity of potential impacts on seabirds from collision of a Project helicopter with seabirds in flight is considered **Low**. On the basis that helicopter traffic will be a consistent presence in the **Direct AOI**, the frequency and duration are considered to be **Continuous** and **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**.

Using the definitions established for assessment of potential impact on seabirds from planned Project activities, the sensitivity of seabirds to impacts from collision with a Project helicopter is considered **Low**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely**, the (pre-mitigation) risk to seabirds from collision of a Project helicopter with seabirds in flight is considered **Minor**. Aside from pilot avoidance of flying seabirds, which is a standard safety protocol and an embedded control, there are no mitigation measures that can be applied to further reduce this potential impact. As such, the residual risk to seabirds from this impact would remain **Minor** (see Table 9.8-1).

Table 9.8-1: Risk Ratings for Unplanned Event Impacts on Seabirds [a]

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Seabirds	Unlikely	High	Moderate	Implement OSRP	Minor
Flaring	Seabirds	Possible	Low	Minor	None	Minor
Discharge of untreated wastewater from the FPSO	Seabirds	Unlikely	Low	Minor	None	Minor
Vessel strike	Seabirds	Unlikely	Low	Minor	None	Minor
Helicopter strike	Seabirds	Unlikely	Low	Minor	None	Minor

[a] Excludes listed seabirds, which are covered in Section 9.5, Protected Areas and Special Status Species [Unplanned Events]

9.9. MARINE MAMMALS

As indicated in Table 9.1-6, the unplanned events with the potential for measurable impacts on marine mammals include a marine oil spill, a coastal fuel spill, a collision of a Project vessel with a marine mammal, and a discharge of untreated wastewater from the FPSO.

9.9.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Tables 7.5-5 and 7.5-6 contain the definitions for intensity of impact and sensitivity of receptor, respectively, for impacts on marine mammals.

9.9.2. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, stochastic oil spill modeling for the Most Credible WCD and Maximum WCD scenarios indicates a 5 to 40 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 1 and a 5 to 10 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 2. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain offshore of Guyana for the Most Credible WCD scenario and for the Maximum WCD (Jun–Nov) scenario. Deterministic modeling predicts impact across the majority of the Region 1 shoreline for the (Dec–May) Maximum WCD scenario. Modeling mitigation under this scenario predicts a reduction in the predicted length of shoreline impact in Region 1, but the predicted length still represents the majority of the Region 1 shoreline. The deterministic modeling analysis does not predict shoreline impacts in Guyana outside of Region 1 for either the Most Credible WCD or Maximum WCD scenarios, regardless of season or the effects of mitigation. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

Twenty-nine species of marine mammals, including 11 species of dolphins and 18 species of whales, are known to occur offshore Guyana. These include several species that have special conservations status (Table 7.5-2). As described in Section 7.5.2, Existing Conditions—Marine Mammals, the most commonly identified species during PSO surveys in the Stabroek Block conducted from 2015 through 2021 include pantropical spotted dolphins (*Stenella attenuate*), spinner dolphins (*Stenella longirostris*), common bottlenose dolphins (*Tursiops truncatus*), and clymene dolphins (*Stenella clymene*). The two most commonly identified whales include short-finned pilot whales (*Globicephala macrorhynchus*) and sperm whales (*Physeter macrocephalus).* There is little available information on the population size or seasonal distribution of marine mammals in the region.

Marine mammals are vulnerable to oil contamination in a variety of ways, including mortality, reduced growth rates, and reproductive success (Mearns et al 2018, Helm et al. 2015). Marine mammals may be exposed to oil through inhalation, ingestion, and dermal pathways. Oil contamination can occur when they surface to breathe or breach in an area with oil. Exposure to oil may harm their respiratory tissue and eyes, and increase their susceptibility to infections. The risk to marine mammals would be greatest close to the spill location, where a higher proportion of volatile compounds is still present in and around the surface slick. The impacts of oil contamination can vary by species. For instance, baleen whales may be more susceptible to such impacts than toothed whales because of the potential for oil to foul their baleen plates if the whales filter-feed in the oil spill vicinity. In addition to direct impacts, an oil spill may also indirectly impact marine mammals through increased exposure to sound and risk of injury from strikes by response vessels.

Based on the total number of visual and acoustic detections documented during PSO surveys in and near the Project AOI from 2015 through 2021 (see Section 7.5.2, Existing Conditions—Marine Mammals), the risk from an oil spill to marine mammals would likely be highest in December through May and lowest in June through November. During the summer, dolphins and whales would both be at risk, but based on a higher frequency of dolphins during this

season the risk to dolphins would be higher than to whales. If a spill were to occur in the December to May season, the risk would shift almost entirely to dolphins, as the predicted swept area would shift to the comparatively shallower continental shelf,[16] where only a few whales have been detected.

Based on the potential impacts on marine mammals from oil spills described above and using the definitions established for assessment of potential impacts on marine mammals from planned Project activities, the intensity of potential impacts of an unmitigated and mitigated marine oil spill on marine mammals is considered **High**. The geographic extent of an unmitigated and mitigated loss-of-well-control event would encompass portions of the **Indirect AOI**. On the basis that impacts on marine mammals from a loss-of-well-control event would persist as long as the spill remained unmitigated, the frequency is considered to be **Continuous**. Even without mitigation, the marine environment would gradually recover to some extent—depending on the degree of oiling—but impacts could still persist beyond a year, yielding a **Long-term** duration.

Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**. Using the definitions established for assessment of potential impact on marine mammals from planned Project activities, the sensitivity of marine mammals to impacts from an unmitigated marine oil spill is considered **Medium**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the pre-mitigation risk to marine mammals from a marine oil spill is considered **Moderate**.

Effective implementation of the OSRP limits the geographic extent of the oil spill, the duration over which the spill would be present on the water surface, and the number of individual marine mammals potentially impacted. As such, this would be expected to reduce the intensity of the impact of a mitigated oil spill on marine mammals to **Medium** and the duration of the spill event to **Medium-term**. This results in a reduced magnitude rating of **Medium** for a mitigated oil spill. Combined with the sensitivity rating of **Medium** assigned for potential impacts on marine mammals from planned activities, this yields a consequence/severity rating of **Medium**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the residual risk to marine mammals from a mitigated marine oil spill would be **Minor**.

9.9.3. Coastal Fuel Spill

As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, an unmitigated coastal fuel spill that reaches a Guyana shoreline would likely only happen near the shorebases to be used by the Project, which are located near the mouth of the Demerara River. A temporary, visible sheen from fuel on the water surface may occur, and water quality would be temporarily impaired in a localized area, but long-term or ecosystem-level impacts on marine

[16] The relatively shallow area of seabed extending from the coast to the edge of the continental slope

mammal habitat would not likely occur because a coastal fuel spill is expected to be contained within a small area and controlled in a short period.

Several marine mammals occur in coastal waters and rivers in Guyana and could be impacted by a coastal fuel spill if present in the affected area during or immediately after the spill event, including boto (*Inia geoffrensis*), tucuxi (*Sotalia fluviatilis*), Guiana dolphin (*Sotalia guianensis*), American manatee (*Trichechus manatus*), and common bottlenose dolphin. Impacts to riverine mammals are described in detail in Section 9.10, Riverine Mammals, and therefore will not be discussed further in this section. An unmitigated coastal fuel spill in the lower Demerara River could affect marine mammals in ways similar to a marine oil spill. Fewer marine mammals are expected to occur in the lower Demerara River where exposure to a coastal fuel spill could occur than in the open ocean, but if these species were present in a confined area like the Demerara River if a spill occurred, they would have reduced ability to avoid contact with spilled fuel compared to the open ocean.

The marine mammals that occur in Guyanese coastal waters are generally long-lived species that may take up to a decade to reach maturity and that reproduce at low rates. These factors limit the rate at which dead individuals can be replaced, so the loss of a few individuals could be significant. However, the coastal area has likely been exposed to small fuel spills in the past and marine mammals would be able to move farther offshore to avoid the effects of a localized spill. Coupled with the likely small area of impact from a coastal fuel spill and the expected lower number of individuals to be impacted from an unmitigated coastal spill, the intensity of potential impacts on marine mammals from an unmitigated coastal fuel spill would likely be **Medium**. The geographic extent of a coastal fuel spill would include the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the fuel spill weathers), and because the impacts of an unmitigated coastal fuel spill could—depending on the volume of release—continue over several weeks, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Using the definitions established for assessing potential impacts on marine mammals from planned Project activities, the sensitivity of marine mammals that could potentially be impacted by a coastal fuel spill is rated **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Medium**. In combination with a likelihood rating of **Unlikely** for a coastal fuel spill, the overall pre-mitigation risk to marine mammals from an unmitigated coastal fuel spill would be **Minor**.

Coastal fuel spills would be quickly controlled and contained because of the relatively small volume of the spill and the ready access to spill control equipment. These impacts would generally be temporary, limited in area and volume of oil released, and readily mitigated, with rapid habitat recovery expected. Accordingly, with implementation of the OSRP and assuming a low volume spill, the intensity of potential impacts on marine mammals from a mitigated coastal fuel spill would likely be reduced to no more than **Medium**. This leads to a magnitude rating of **Medium**, and a consequence/severity rating of **Medium**. In combination with a likelihood rating

of **Unlikely** for a coastal fuel spill, the overall residual risk to marine mammals from an unmitigated coastal fuel spill would be **Minor** (see Table 9.9-1).

9.9.4. Vessel Collision

As described in Section 9.1.10.2, Vessel Collision with a Marine Mammal, marine mammals are inherently vulnerable to vessel strikes when they swim near the surface or surface to breathe or feed. This vulnerability increases in shallow, nearshore areas, where opportunities to maneuver are reduced by the water depth. Vessel collisions or strikes to whales are among the greatest threats and causes of death of whales, especially in regions with high aggregations (feeding and breeding) of whales and high volumes of vessel traffic (Peel et al. 2018). A vessel encounter can cause harm, injury, or mortality, and temporary behavior changes to marine mammals. Larger, faster vessels moving at speeds above 13 knots (24 kilometers per hour) pose a greater risk for collision with a marine mammal than smaller, slower vessels, which are also more maneuverable (Laist et al. 2001). Currently, no records of vessel collisions with marine mammals are known for Guyana, but this lack of reports does not necessarily indicate vessel collision with marine mammals does not occur since such incidents may not be reported or vessel operators may not be even aware of a collision event.

The potential for any Project-related vessel to collide with a marine mammal was considered when assessing the potential impact associated with vessel collisions. The potential for the FPSO to collide with marine mammals is virtually non-existent because the FPSO will be stationary for the entire operational life of the Project; however other Project-related vessels have the potential to encounter marine mammals in any portion of the AOI. As described in Section 7.5.2, Existing Conditions—Marine Mammals, the largest and least maneuverable marine mammals (i.e., the large whales) are only found in the deep portions of the Project AOI. Smaller species such as the spinner dolphin, common bottlenose dolphin, and pantropical spotted dolphin are found within the PDA and the continental shelf. Vessel speeds will be lower within the PDA than during transit to/from the shorebase, so only a portion of the Project AOI outside the PDA would have vessels operating at higher speeds (over 13 knots) that could reduce their ability to avoid a collision with a marine mammal and have a reasonable expectation of encountering a large whale. Support vessels will operate at higher speeds when transiting the continental shelf, but the only marine mammals they are likely to encounter on the continental shelf are dolphins and short-finned pilot whale, which are agile by comparison and much more likely to avoid a vessel strike than the larger whales.

As an embedded control, EEPGL will provide awareness training to Project-dedicated marine personnel to recognize and spot marine mammals, and will provide standing instructions to Project-dedicated vessel masters on what to do if they encounter marine mammals while in transit (e.g., reduce vessel speed or deviate from course, as needed, to lower the probability of a collision with a marine mammal).

Using the definitions established for assessment of potential impact on marine mammals from planned Project activities and considering the above information, the intensity of potential impacts on marine mammals as a result of vessel collision is considered **Medium**. The

geographic extent of potential vessel collision with a marine mammal would be limited to the **Direct AOI**. On the basis that vessel traffic will be a consistent presence in the **Direct AOI**, the frequency and duration are considered to be **Continuous** and **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Using the definitions established for sensitivity of marine mammals to impacts from planned Project activities, the sensitivity of marine mammals is considered **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Medium**.

As stated previously, the few large whales observed during surveys occur in the PDA where vessels will be moving at lower speeds, and embedded controls will minimize the potential for a vessel collision. If it were to occur, it would be at most infrequent. However, given the length of the Project life cycle (at least 20 years), a collision with a marine mammal is considered **Possible**, so the overall pre-mitigation risk to marine mammals, particularly whales, from a vessel collision is considered **Moderate**. All of the available measures to minimize the risk of a collision have been included in the Project design as embedded controls and are therefore reflected in the initial risk rating. Accordingly, the residual risk rating is maintained at **Moderate** (see Table 9.9-1).

9.9.5. Discharge of Untreated Wastewater from the FPSO

A discharge of untreated wastewater from the FPSO would only occur under an equipment failure scenario, and would involve the release of untreated wastewater directly overboard through an outfall. The untreated discharge would have localized impacts on water quality, but it is expected that the release would be rectified and controlled within a short period of time. The primary constituents in wastewater would include solids and biodegradable organics (usually measured in terms of biochemical oxygen demand), carbon, nutrients (primarily nitrogen and phosphorous), and pathogens, such as coliform. The affected area would likely be somewhat larger than the mixing zone associated with normal operations, but not large enough to cause a regional significant event. As described in Section 9.1.11, Discharge of Untreated Wastewater from the FPSO, modeling results show that a temporary release of untreated wastewater would result in a plume of limited extent and that constituent concentrations never exceed the end-of-pipe levels recommended by the IMO's 2012 *Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants* (IMO 2012).

Marine mammals in the area at the time of the accidental release could be exposed to the wastewater plume by ingesting wastewater during foraging or unintentionally swimming through the plume and having it contact their skin (dermal). However, given the constituents and associated concentrations, the wastewater plume would not expose marine mammals to concentrations resulting in toxic effects (injury or mortality). Untreated wastewater discharge is a major form of marine pollution in some locations around the world where wastewater treatment facilities are either limited or non-existent. Under specific conditions and concentrations, untreated wastewater discharge can harm marine organisms, especially in coastal waters with

limited flow or water exchange (NRC 1993). An untreated wastewater discharge from the FPSO would occur in the open ocean and the discharge would be expected to rapidly assimilate into the ocean, significantly limiting potential exposure of a marine mammal to the discharge.

The geographic extent of an accidental discharge of untreated wastewater from the FPSO would be limited to the **Direct AOI**. Using the definitions established for assessment of potential impact on marine mammals from planned Project activities, the intensity of potential impacts of a discharge of untreated wastewater from the FPSO is considered **Negligible**. The frequency of a discharge of untreated wastewater from the FPSO would be **Episodic** because, if it were to occur, it would occur infrequently. The duration of this impact would be **Short-term**, as the discharge would assimilate into the ocean quickly and occur for less than a week in aggregate for the life of the Project (at least 20 years). Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible**.

Using the definitions established for assessment of potential impacts on marine mammals from planned Project activities, the sensitivity of marine mammals to impacts from a discharge of untreated wastewater from the FPSO is considered **Medium**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. Multiple redundancies in the FPSO's wastewater management system would have to fail simultaneously in order for untreated wastewater to be released to the environment, so such an event is considered **Unlikely**. These factors yield a pre-mitigation risk rating to marine mammals from a discharge of untreated wastewater from the FPSO of **Minor** (see Table 9.9-1). Response actions would focus on identifying and rectifying the condition that caused the release rather than recovery of discharged material, and the residual risk would therefore be retained at **Minor**.

Table 9.9-1: Risk Ratings for Unplanned Event Impacts on Marine Mammals

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Mammals	Unlikely	High	Moderate	Implement OSRP	Minor
Coastal fuel Spill	Marine Mammals	Unlikely	High	Moderate	Implement OSRP	Minor
Vessel Collision	Marine Mammals	Possible	Medium	Moderate	None	Moderate
Untreated FPSO Wastewater Discharge	Marine Mammals	Unlikely	Low	Minor	None	Minor

9.10. RIVERINE MAMMALS

As indicated in Table 9.1-6, the unplanned events with the potential for measurable impacts on riverine mammals include a marine oil spill, a coastal fuel spill, and collision of a Project vessel

with a riverine mammal. Section 9.7, Coastal Wildlife, discusses potential effects on other coastal wildlife species.

9.10.1. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). As described in Section 9.1.5, stochastic oil spill modeling for the Most Credible WCD and Maximum WCD scenarios indicates a 5 to 40 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 1 and a 5 to 10 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 2. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain offshore of Guyana for the Most Credible WCD scenario and for the Maximum WCD (Jun–Nov) scenario. Deterministic modeling predicts impact across the majority of the Region 1 shoreline for the (Dec–May) Maximum WCD scenario. Modeling mitigation under this scenario predicts a reduction in the predicted length of shoreline impact in Region 1, but the predicted length still represents the majority of the Region 1 shoreline. The deterministic modeling analysis does not predict shoreline impacts in Guyana outside of Region 1 for either the Most Credible WCD or Maximum WCD scenarios, regardless of season or the effects of mitigation. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

Three of the six riverine mammal species known to occur in Guyana—the American manatee, the neotropical otter, and the Guiana dolphin—occur in coastal environments during at least part of the year, and would be vulnerable to exposure from an unmitigated or mitigated marine oil spill that reached the Guyana coastline during those times. Very little is known about the population size and distribution of the American manatee and neotropical otter along Guyana's coastline, but both species have been documented in Region 1 within the SBPA (Mendonca et al. 2006; EPA et al. 2004; see Appendix P, Flora and Fauna of Shell Beach). The Guiana dolphin has also been documented along the coast of Guyana and is a tropical coastal-estuarine habitat specialist, preferring shallow coastal waters along the continental shelf (de Jesus Lobo et al. 2021). The other three riverine mammal species that occur in Guyana—the giant otter, gray river dolphin, and Amazon River dolphin—are freshwater species that are not likely to be encountered within areas that could be affected by a marine oil spill (Barnett et al. 2000).

Limited information is available describing the impacts of oil spills on the American manatee and there are no published accounts linking an oil spill or dispersants to mortality of a manatee (Fingas 2015). Nonetheless, the manatee is highly vulnerable to an oil spill along the coast and rivers because manatees are aquatic herbivores that feed on seagrass and other aquatic vegetation at or near the water surface, so when feeding they could ingest oil that is present on or near the water surface (Fingas 2015; Helm et al. 2015). Further, manatees do not make long migrations because they are limited by water temperature and food. As such, an oil spill that reached coastal waters could negatively impact the available food supply for this species (Fingas 2015; Helm et al. 2015). In addition, exposure to oil could directly impact a manatee by coating its skin and possibly causing toxic effects, such as irritation to the nose, eyes, and

respiratory system (Fingas 2015). For many of the same reasons, neotropical otters and Guiana dolphins can also be negatively impacted by oil spills, especially if the oil is carried on incoming tides into a river or estuary. An oil spill that reaches the coastline could impact these species' prey, which generally consists of fish and crustaceans. In the unlikely event of a marine oil spill reaching the coast, American manatees and neotropical otters occurring along the coastline in Region 1 and 2 exposed to a marine oil spill would be expected to move up river (inland) to avoid the effects of oil contamination. Guiana dolphins would also be expected to move along the coast, or potentially up river, to avoid the effects of oil contamination.

Using the definitions established for assessment of potential impact to riverine mammals from planned Project activities, the intensity of potential impacts from an unmitigated marine oil spill on riverine mammals is considered **Low** because any riverine mammals present along the coastline in Region 1 and 2 during a spill event could move upriver away from the spill zone, limiting the number and exposure time of individuals that could be impacted. The geographic extent of an unmitigated or mitigated loss-of-well-control event would encompass portions of the **Indirect AOI**. On the basis that impacts on riverine mammals from an unmitigated or mitigated loss-of-well-control event would persist until mitigation efforts were complete, the frequency is considered to be **Continuous**. Even without mitigation, the coastal environment would gradually recover to some extent—depending on the degree of oiling—but impacts could still persist beyond a year, yielding a **Long-term** duration. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Small**.

Using the definitions established for assessing potential impacts on riverine mammals from planned Project activities, the sensitivity of riverine mammals to impacts from an unmitigated marine oil spill is considered **Medium**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the pre-mitigation risk to coastal habitats is considered **Minor**.

Mitigation for a marine oil spill would involve implementation of the OSRP. Deterministic modeling for both loss-of-well-control scenarios predicts that a mitigated spill would not reach the Guyana shoreline or come close enough to the Guyana shoreline to impact riverine mammal habitat. On this basis, the intensity of potential impacts on riverine mammals in Guyana from a mitigated marine oil spill would be **Negligible** for all spill scenarios considered. This leads to a magnitude rating of **Negligible** and a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall residual risk to riverine mammals from a mitigated marine oil spill would be **Minor** (see Table 9.10-1).

9.10.2. Coastal Fuel Spill

As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, an unmitigated coastal fuel spill that reaches a Guyana shoreline would likely only happen near the shorebases to be used by the Project, which are located near the mouth of the Demerara River. Of the six riverine mammal species known to occur in Guyana, only the American manatee and river otter

are known to occur, and the Guiana dolphin to potentially occur, in the brackish/intertidal waters of the Demerara Harbour and the lower Demerara River where a coastal spill could occur. In the event of a coastal fuel spill, a temporary, visible sheen on the water surface may occur and water quality would be temporarily impaired in a localized area, but long-term or ecosystem-level impacts on riverine mammal habitat would not occur. An unmitigated coastal fuel spill in the lower Demerara River could affect American manatees and neotropical otters in a similar way to that described above for a marine oil spill.

As described in Section 7.6, Riverine Mammals, the riverine mammal species with the highest probability of encountering a coastal oil spill should one occur, are generally long-lived species that may take up to a decade to reach maturity and that reproduce at low rates. These factors limit the rate at which dead individuals can be replaced, so the loss of a few individuals could be significant. However, the coastal area has likely been exposed to small fuel spills in the past, and marine mammals would be able to move farther offshore to avoid the effects of a localized spill. Coupled with the likely small area of impact from a coastal fuel spill and the expected lower number of individuals to be impacted from an unmitigated coastal spill, the intensity of potential impacts on riverine mammals from an unmitigated coastal fuel spill would likely be **Medium**. The geographic extent of an unmitigated coastal fuel spill would likely be limited to the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly over time as the fuel weathers), and because the impacts of an unmitigated coastal fuel spill could—depending on the volume of material released—continue for several weeks, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Using the definitions established for assessing potential impacts on riverine mammals from planned Project activities, the sensitivity of riverine mammals that could potentially be impacted by a coastal fuel spill is rated **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Medium**.

In combination with a likelihood rating of **Unlikely** for a coastal fuel spill, the overall pre-mitigation risk to riverine mammals from an unmitigated coastal fuel spill would be **Minor**.

Coastal fuel spills would be quickly controlled and contained because of the relatively small volume of the spill and the ready access to spill control equipment. These impacts would generally be temporary, limited in area due to the small volume of fuel released, and readily mitigated, with rapid habitat recovery expected. Accordingly, with implementation of the OSRP and low volume spill, the intensity of potential impacts on riverine mammals from a mitigated coastal fuel spill would likely be reduced to a **Negligible** level. This leads to a magnitude rating of **Negligible**, and a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for a coastal fuel spill, the overall residual risk to riverine mammals from an unmitigated coastal fuel spill would be **Minor** (see Table 9.10-1).

9.10.3. Vessel Collision

Riverine mammals likely to occur within the riverine zone of the PDA are vulnerable to vessel collision when they surface to breathe or to feed. This vulnerability increases in shallow water, where there are fewer opportunities to maneuver compared to the open ocean. Vessel routes within the PDA are restricted to the channel of the Demerara Harbour, which is relatively deep, thereby increasing the opportunity for riverine mammals to maneuver away from passing vessels. Six riverine mammal species potentially occur in Guyana; however, the most likely to be encountered include the American manatee, river otter, and the Guiana dolphin. Each of these species can be found in the brackish/intertidal waters of the Demerara Harbour and the lower Demerara River, where Project-related vessel traffic will occur. Only the manatee has been documented in the riverine mammal survey events conducted from 2019 to 2021.

The neotropical otter, if present in the lower Demerara River, would most likely occur along the banks of the river and along the coastline of the Demerara Harbour. Vessel routes within the PDA are restricted to the main channel of the Demerara Harbour and river where neotropical otters are not expected to regularly occur. Further, otters are very agile swimmers and would be expected to swim away from approaching vessels, avoiding collision. As such, vessel collision with a neotropical otter is not expected to occur and is not discussed further.

The Guiana dolphin would likely spend most of its time in the main channel when present in the lower Demerara River. Its proclivity to occur in the main channel would expose it to a greater risk of ship strikes than neotropical otter, but this species is also agile and, because it spends a large proportion of its time at the surface of the water, would be visible and likely swim away from approaching vessels to avoid collisions. Therefore, vessel collisions with Guiana dolphins are not expected to occur.

The American manatee would be susceptible to vessel collision within the lower Demerara River. It is well documented that manatees are highly vulnerable to vessel collision, and vessel collision is one of the leading causes of death and considered the greatest adverse impact on the population growth rate of the Florida manatee population (Deutsch and Reynolds 2012; Runge et al. 2007). Rangewide, approximately half of adult manatee mortalities are attributable to human-related causes, primarily watercraft collisions (Ackerman et al. 1995; Deutsch et al. 2002). Less is known about the degree to which vessel collision affects the American manatee population in the Caribbean, but vessel collision is listed by IUCN as one of the key threats to this subpopulation of manatees (IUCN 2021). In Florida, even with vessel restrictions aimed at reducing vessel collisions with manatees (e.g., no wake zones and reduced boat speeds), around 30 percent of annual manatee mortality is attributable to vessel collisions (Aipanjiguly et al. 2003; Nowacek et al. 2004). One of the reasons that manatees are frequently struck by vessels is that manatees spend most of their time at the water surface or within several feet of the water surface, which is within the strike depth of most vessels (Edwards et al. 2016). Rycyk et al. (2018) reported that manatees responded to boats, changing their orientation, depth, and fluking behavior (i.e., using their tail fluke for movement or positioning in the water) most often when a boat approached closely (within about 10 meters [30 feet]). Manatees were also more likely to change their depth or swimming behavior when not on a seagrass bed. Boat speed did

not affect the occurrence or intensity of manatee response, but slower passes allowed the manatee more time to respond, and behavioral change occurred earlier relative to the time of the boat's closest point of approach. Faster boats therefore likely pose a greater risk of collision with manatees than slower boats.

Collision between a Project vessel and an American manatee could cause injury or mortality to the affected individual or temporary behavioral changes, but manatees in this area are accustomed to the presence of vessels and are therefore expected to exhibit some level of avoidance behavior when vessels are passing through. No records of vessel collisions with manatees are known from Guyana, although the lack of documentation of vessel collisions with manatees does not necessarily indicate that this impact does not occur, since such incidents may not be reported or vessel operators may not be aware of a collision event. Data from EEPGL's harbor mammal surveys suggest that manatees in the lower Demerara River tend to frequent the nearshore areas outside the main channel. Very few manatees are expected to occur in the main channel of the lower Demerara River, so vessel collision with a manatee, if it were to occur, would be very infrequent.

As an embedded control, EEPGL will provide awareness training to Project-dedicated marine personnel to recognize signs of riverine mammals at the river or harbor surface, and will provide standing instructions to Project-dedicated vessel masters to avoid riverine mammals while in transit and reduce speed or deviate from course, as needed, to reduce the probability of collision with a riverine mammal.

Using the definitions established for assessment of potential impact to riverine mammals from planned Project activities, and considering the above information, the intensity of potential impacts on riverine mammals as a result of vessel collision is considered **Low**. The geographic extent of potential vessel collision with a riverine mammal would be limited to the **Direct AOI**. On the basis that vessel traffic will be a consistent presence in the **Direct AOI**, the frequency and duration are considered to be **Continuous** and **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**.

Using the definitions established for assessment of potential impacts on riverine mammals from planned Project activities, the sensitivity of riverine mammals is rated **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/ severity rating of **Low**.

As stated previously, manatees tend to occur most frequently outside the main river channel, so a vessel collision with a manatee, if it were to occur, would be very infrequent. However, given the length of the Project life cycle (at least 20 years), a collision with a riverine mammal is considered **Possible**, so the overall pre-mitigation risk to riverine mammals from a vessel collision is considered **Minor**. All of the available measures to minimize the risk of a collision have been included in the Project design as embedded controls and are therefore reflected in the initial risk rating. Accordingly, the residual risk rating is maintained at **Minor** (Table 9.10-1).

Table 9.10-1: Risk Ratings for Unplanned Event Impacts on Riverine Mammals

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Riverine Mammals	Unlikely	Low	Minor	Implement OSRP	Minor
Coastal Fuel Spill	Riverine Mammals	Unlikely	Medium	Minor	Implement OSRP	Minor
Vessel Collision	Riverine Mammals	Possible	Low	Minor	None	Minor

9.11. MARINE TURTLES

As indicated in Table 9.1-6, the unplanned events with the potential for measurable impacts on marine turtles include a marine oil spill, a collision between a Project vessel and a marine turtle, and a discharge of untreated wastewater from the FPSO. Although marine turtles come ashore to nest, the only coastal oil spills that could occur as part of this Project would be confined to the Demerara River where there are no nesting beaches; therefore, coastal spills have been scoped out of the impact assessment for marine turtles.

9.11.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Tables 7.7-5 and 7.7-6 in Section 7.7, Marine Turtles, contain the definitions for intensity of impact and sensitivity of receptor, respectively, for impacts on marine turtles.

9.11.2. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, oil spill modeling was completed for two loss-of-well-control scenarios (i.e., Most Credible WCD and Maximum WCD). Deterministic oil spill modeling for both loss-of-well-control scenarios, which examines scenarios with the fastest shoreline impact timing, predicts that a spill would generally travel northwest or west (depending on the case and the season) from the source based on the prevailing wind and current. If the swept area were to encroach onto the continental shelf,[17] the affected area within Guyanese waters would extend along the continental shelf off Regions 1 through 6 under all scenarios. The predicted extent of the oil's encroachment onto the continental shelf changes seasonally, with oil reaching the coast (and therefore a larger portion of the continental shelf) in winter. The implication of these model results is that marine turtles in the open ocean would have the highest potential for exposure to oil as the result of a loss-of-well-control event, but that under certain conditions, marine turtles on the continental shelf or near the shore could be exposed as well.

Stochastic modeling for both scenarios indicates a 5 to 40 percent probability of an unmitigated spill reaching a Guyana shoreline in Region 1 and a 5 to 10 percent probability of an unmitigated spill reaching Region 2 depending on wind and current conditions at the time of the spill. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain offshore

[17] The relatively shallow area of seabed surrounding extending from the coast to the edge of the continental slope

of Guyana for the Most Credible WCD scenario and for the Maximum WCD (Jun–Nov) scenario. Deterministic modeling predicts impact across most of the Region 1 coast for the (Dec–May) Maximum WCD scenario. Modeling of a mitigated Maximum WCD scenario indicates that mitigation would reduce the length of shoreline impacted compared to an unmitigated scenario, but most of the Region 1 shoreline would be affected. The deterministic modeling analysis does not predict shoreline impacts in Guyana outside of Region 1 for either the Most Credible WCD or Maximum WCD scenarios, regardless of season or the effects of mitigation. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

Region 1 provides nesting habitat for four species of marine turtles (see Section 7.7, Marine Turtles) (Alvarez-Varas et al. 2016). Stochastic modeling indicates that the minimum time for oil to reach the Guyana shoreline in this area would be between 5 and 10 days.

Several aspects of marine turtle biology and life history characteristics place them at high risk of impacts associated with a marine oil spill (Ruberg et al. 2021; Yender and Mearns 2003) in the unlikely event that a spill were to occur. Marine turtles nest on sandy beaches. If such beaches were to become oiled, the laid eggs may be contaminated from oil entering the nest or adult turtles picking up oil and depositing it in the nest as they cross the beach. The eggs are susceptible to oil through absorption, which can inhibit their development depending on various factors such as oil concentration and exposure duration (Shaver et al. 2021; USFWS 1982). The U.S. Fish and Wildlife Service (USFWS 1982) and Shaver et al. (2021) reported that hatchling morphology (smaller hatchlings) was adversely impacted by the oil amount (increasing amounts). Besides oiling of nests, newly hatched turtles can be exposed to oil after emerging from their nests and crossing an oiled beach on their way to the water. Hatchlings and small surface-pelagic juveniles have shown increased vulnerability to oil spills because oil tends to collect in specific habitat used during this developmental phase, and newly hatched turtles have limited ability to avoid or escape surface oil due to their small size (Wallace et al. 2020). Each life stage of marine turtles (hatchlings, juvenile, sub-adults, and adults) can be exposed to oil through inhalation, ingestion, and dermal contact with varying effects (USFWS 1982; Mitchelmore et al. 2017; Wallace et al. 2017).

Several aspects of marine turtle behavior compound their biological susceptibility to oil:

- Lack of avoidance behavior—there is no evidence that marine turtles will avoid areas of oil contamination (NOAA 2010);
- Indiscriminate feeding—marine turtles have a habit of ingesting floating objects (NOAA 2010; Schuyler et al. 2012), which can include the ingestion of oil-fouled food and floating tar balls they mistake for food; and
- Large pre-dive inhalations—if turtles surface to breathe in a fresh slick, the oil can impact their eyes and damage their airways and/or lungs, especially with their large pre-dive breaths, which can introduce airborne toxins deep into their respiratory system (NOAA 2010). This risk will be greatest in areas where fresh oil has high levels of aromatic compounds and volatilizes directly above the slick.

Using the definitions established for assessing potential impacts on marine turtles from planned Project activities, the intensity of impacts from an unmitigated marine oil spill is considered **High**.

The geographic extent of an unmitigated loss-of-well-control event would encompass portions of the **Indirect AOI**. On the basis that impacts on marine turtles from an unmitigated loss-of-well-control event would persist as long as the spill remained unmitigated, the frequency is considered to be **Continuous**. Even without mitigation, the marine environment and turtles present could recover, but impacts from an oil spill could persist beyond a year, yielding a **Long-term** duration. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**.

Using the definitions established for assessing potential impacts on marine turtles from planned Project activities, the sensitivity of marine turtles in the areas with the potential to be affected by a marine oil spill is considered **High**. This takes into consideration their susceptibility to oil contamination, the presence of individual turtles, important nesting sites in the Project AOI, and their protected status.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the pre-mitigation risk to marine turtles is considered **Moderate**.

Effective implementation of measures to stop the spill and/or contain it would reduce the geographic extent of the spill and the duration that the spill would be present on the water surface. Reducing the volume and duration of a spill could reduce the number of individual turtles potentially impacted. If applied, dispersants may increase the geographic extent of the slick and/or concentrations of oil entrained in the upper portions of the water column and thus marine turtles' exposure to near-surface entrained oil. There are few studies on the potential effects of dispersants on marine turtles; however, the NEBA process would optimize use of dispersants such that the benefits would be expected to outweigh the negative effects of increased concentrations of emulsified or entrained oil near the surface (Frasier et al. 2020). Accordingly, the intensity of such an impact would be reduced to **Medium** for marine turtles. The geographic extent of an unmitigated loss-of-well-control event would include portions of the **Indirect AOI**. On the basis that the loss-of-well-control event would continue for several weeks, the frequency is considered to be **Continuous**. Assuming mitigation of the spill, the effects would be reduced to less than a year, so the duration would be reduced to **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of a mitigated marine oil spill of **Medium** for marine turtles.

With the sensitivity rating for marine turtles rated as **High**, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High** for marine turtles. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a marine oil spill is considered **Unlikely**, so the overall risk of a marine oil spill to marine turtles would remain **Moderate**.

9.11.3. Vessel Collision

Project support vessels will consist of multiple platform-supply vessels and a fast-supply vessel conducting resupply trips to the FPSO and drill ships, tug vessels supporting tanker-offloading activities, and multi-purpose vessels supporting subsea installation and maintenance activities. Based on current drilling activities and past experience with similar developments, it is estimated that during development drilling and FPSO/SURF installation, marine vessels may make an average of approximately 18 to 21 round trips per week to the Yellowtail PDA. During FPSO/SURF production operations, it is estimated that this number will be reduced to approximately three to five round-trips per week. The vessels will be loaded and offloaded at shorebase facilities in Guyana and/or Trinidad.

Similar to marine mammals, marine turtles are vulnerable to vessel strikes when they swim near the surface or surface to breathe because they are within the strike zone of vessels. This vulnerability extends to shallow, nearshore areas, where turtles congregate prior to coming ashore to nest. Studies of boat strikes on marine turtles are scarce (Denkinger et al. 2013). However, as described in Section 9.1.10.3, Vessel Collision with a Marine Turtle, both Hazel et al. (2007) and Wirsing et al. (2008) determined that turtles have the awareness and agility to avoid slower-moving vessels (less than 15 knots [27.8 kilometers per hour]). Vessel speeds will be lower within the PDA than during transit to/from the shorebases, including along the continental shelf where the water is shallower in proximity to the shoreline. No planned Project vessel movements will occur on the western portion of Guyana's continental shelf near the marine turtles' nesting beaches, and hence, where they congregate during the pre-nesting period. Therefore, Project vessels do not have a reasonable expectation of encountering a mature turtle with eggs on her way to the nesting beaches, or encountering dense congregations of turtles; however, encounters with all ages of turtles during migration or foraging are possible within the Direct AOI.

As an embedded control, EEPGL will provide standing instructions to Project-dedicated vessel masters on what to do if they encounter marine turtles while in transit (i.e., reduce vessel speed or deviate from course, when possible, to lower the probability of a collision with a marine turtle). Vessel masters will be instructed to reduce their speed within 300 meters (984 feet) of observed marine turtles and will not approach within 100 meters (328 feet) of the animals.

Using the definitions established for assessment of potential impact on marine turtles from planned Project activities and considering the above information, the intensity of potential impacts on marine turtles as a result of vessel collision is considered **Medium**. The geographic extent of potential vessel collision would be limited to the **Direct AOI**. On the basis that vessel traffic will be a consistent presence in the **Direct AOI**, the frequency and duration are considered to be **Continuous** and **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Using the definitions established for sensitivity of marine turtles to impacts from planned Project activities, the sensitivity of marine turtles to a vessel strike was assessed based on the conservative assumption that a Critically Endangered or Endangered species would be affected,

which assigns a sensitivity rating of **High**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **High**.

Although no formal population estimates for the number of turtles occurring in the region at any given time of the year exist, based on the number of turtles (17) observed during nearly 5 years of Marine Mammal Observer data collected during various surveys conducted within the Stabroek Block and between the Stabroek Block and the Guyana coast (see Section 7.7, Marine Turtles), the abundance of turtles offshore Guyana is expected to be low. The likelihood of a vessel colliding with a marine turtle is based on the chance that a Project vessel's path would cross that of a surfacing turtle when either in the PDA or when transiting between the shorebases and the PDA, and that the vessel could not maneuver to avoid the turtle. Hence, a collision with a marine turtle is considered **Unlikely**, so the overall pre-mitigation risk to marine turtles from a vessel collision is considered **Moderate**. All of the available measures to minimize the risk of a collision have been included in the Project design as embedded controls (Section 2.14), so the residual risk rating remains **Moderate** (see Table 9.11-1).

9.11.4. Discharge of Untreated Wastewater from the FPSO

A discharge of untreated wastewater (i.e., sewage or black water) from the FPSO would only occur under an equipment failure scenario and involve a release of untreated wastewater directly overboard. Such a discharge would have localized impacts on water quality, but conditions that could cause such a release would generally be rectified within a short period. The primary constituents in wastewater include solids and biodegradable organics (usually measured in terms of biochemical oxygen demand), carbon, nutrients (primarily nitrogen and phosphorous), and pathogens such as coliform. The affected area of ocean would be somewhat larger than the areas affected by normal operations, but not so large that the event would be regionally significant. As described in Section 9.1.11, Discharge of Untreated Wastewater from the FPSO, modeling results show that a temporary release of untreated wastewater would result in a plume of limited extent and that constituent concentrations would never exceed the end-of-pipe levels recommended by the IMO's 2012 *Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants* (IMO 2012).

A marine turtle foraging in the water or swimming on the water surface could come into dermal contact with the wastewater plume or an individual could ingest wastewater during foraging. The character (constituents and concentration) of the wastewater plume would not expose marine turtles to toxic effects (injury or mortality) and no dermal effects from wastewater contact with a marine turtle's skin would be expected.

The geographic extent of a discharge of untreated wastewater from the FPSO would be limited to the **Direct AOI**. Using the definitions established for assessing potential impacts on marine turtles from planned Project activities, the intensity of potential impacts of a discharge of untreated wastewater from the FPSO is considered **Negligible**. The frequency of a discharge of untreated wastewater from the FPSO would be **Episodic** because it would occur infrequently (if ever). The duration of this impact would be **Short-term**, as it would assimilate into the ocean quickly and not persist at the water surface where turtles surface to breathe. Applying the

methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible**.

Using the definitions established for assessing potential impacts on marine turtles from planned Project activities, the sensitivity of marine turtles to impacts from a discharge of untreated wastewater from the FPSO is considered **High**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. Multiple redundancies in the FPSO's wastewater management system would have to fail simultaneously for untreated wastewater to be released to the environment, so such an event is considered **Unlikely**. These factors yield a pre-mitigation risk rating to marine turtles from a discharge of untreated wastewater from the FPSO of **Minor**.

Response actions would focus on identifying and rectifying the condition that caused the release rather than recovery of discharged material, and the residual risk would be **Minor** (see Table 9.11-1).

Table 9.11-1: Risk Ratings for Unplanned Event Impacts on Marine Turtles

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Turtles	Unlikely	High	Moderate	Implement OSRP	Moderate
Vessel Collision	Marine Turtles	Unlikely	High	Moderate	None	Moderate
Untreated FPSO Wastewater Discharge	Marine Turtles	Unlikely	Low	Minor	None	Minor

9.12. MARINE FISH

As indicated in Table 9.1-6, the unplanned events with the potential for measurable impacts on marine fish include a marine oil spill, a coastal fuel spill, a release of NADF, or a discharge of untreated wastewater from the FPSO.

9.12.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Tables 7.8-4 and 7.8-5 in Section 7.8, Marine Fish, contain the definitions for intensity of impact and sensitivity of receptor, respectively, for impacts on marine fish.

9.12.2. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, stochastic oil spill modeling for the Most Credible WCD and Maximum WCD scenarios indicates a 5 to 40 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 1 and a 5 to 10 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 2. Deterministic oil spill modeling

predicts that an unmitigated oil spill would remain offshore of Guyana for the Most Credible WCD scenario and for the Maximum WCD (Jun–Nov) scenario. Deterministic modeling predicts impact across the majority of the Region 1 shoreline for the (Dec–May) Maximum WCD scenario. Modeling mitigation under this scenario predicts a reduction in the predicted length of shoreline impact in Region 1, but the predicted length still represents the majority of the Region 1 shoreline. The deterministic modeling analysis does not predict shoreline impacts in Guyana outside of Region 1 for either the Most Credible WCD or Maximum WCD scenarios, regardless of season or the effects of mitigation. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

As described in Section 9.1.5, the trajectory of the spilled oil would be influenced by wind and current patterns, which vary seasonally. The extent of the oil's predicted effect on the continental shelf[18] changes seasonally, with the highest probability of oil reaching the coast (and therefore a larger portion of the continental shelf) in winter, but the affected area would be limited to the portion of the continental shelf off Regions 1 and 2 under all scenarios. Based on model results, pelagic, open-ocean fishes would have the highest potential for exposure to oil as the result of a loss-of-well-control event. Under certain conditions, continental shelf species could be exposed as well, and a remote possibility exists for exposure to occur in shallow water where fishes' normal ability to avoid entrained oil would be compromised by water depth.

Potential impacts on marine fish from a marine oil spill are related to both water column concentrations of, and the duration of exposure to, dissolved hydrocarbons (primarily PAHs). Contamination in the water column changes rapidly in space and time, such that potentially harmful exposure levels are brief (i.e., typically hours), except in the case of an ongoing release such as a loss-of-well-control event or slow leak from a vessel. Exposure to microscopic oil droplets may impact aquatic biota either mechanically or as a conduit for exposure to semi-soluble hydrocarbons taken up in the gills or digestive tract via dissolution from the micro-droplets.

Fish are generally only slightly impacted by oil spills because of their limited exposure to surface slicks and the dispersed oil being rapidly diluted to very low concentrations in open water environments. Fish may also actively avoid oil, as they can detect hydrocarbons in the water. Juvenile life stages of marine fish tend to be more susceptible to impacts from oil spills than adults for several reasons:

- Oil tends to concentrate at the surface and near-surface, at least initially following a release.
- Most marine fishes spend at least their initial larval stages in the plankton (referred to as ichthyoplankton).
- Although ichthyoplankton are capable of volitional movement over small scales, they tend to concentrate near the surface (Habtes et al. 2014; de Freitas and Meulbert 2004; Cowen et al. 2000).

[18] The relatively shallow area of seabed surrounding extending from the coast to the edge of the continental slope

- In addition to acute ingestion- and dermal-contact-related impacts, early life stages are also exposed to developmental-related impacts, which may include deformities in heart, jaw, and eye tissues, that may develop over time (NOAA 2015).

Despite the susceptibility of juvenile stages of fish to relatively low concentrations of oil in the water column, high mortality of planktonic life stages of fish would be expected to have minor impacts on the long-term populations of most open-ocean species. Very high natural mortality rates for larval life stages (exceeding 99 percent for most marine fishes) (MBC 2011) suggest that most ichthyoplankton that could be killed during an oil spill event would die naturally from other causes in the absence of a spill. Therefore, localized, high losses of these juvenile life stages rarely equate to any measurable loss of adult life stages in the population.

In the unlikely event of a marine oil spill, implementation of the OSRP may include use of dispersants for certain types of spill scenarios, based on NEBA analysis. The OSRP references the use of the four primary (i.e., most broadly approved and studied) dispersants: Corexit 9500, Corexit 9527A, Finasol OSR 52, and Dasic Slickgone NS. These dispersants have been found to have low toxicity, are effective across a broad range of oil types and environmental conditions, and are readily available globally. For reference, in a 2010 study conducted by the U.S. Environmental Protection Agency, Corexit 9500A was found to be practically non-toxic[19] to *Menidia* spp. (which is commonly used as a biological model representing juvenile marine fish) during standard acute toxicity tests (USEPA 2010). Although it is impossible to predict the exact quantity of dispersant that would be required under every foreseeable oil spill scenario, based on previous industry experience, the loss-of-well-control scenarios identified in the OSRP for which application of dispersants would be recommended could require the application of up to 3,000 m^3 (105,944 cubic feet) of dispersant at the ocean surface and up to 5,000 m^3 (176,573 cubic feet) applied at the well head, depending on how the dispersant is applied, the volume of oil spilled, the relative speed with which other mitigation measures could be applied and their effectiveness, and sea conditions at the time of the spill, as well as other factors. Further discussion of potential impacts on marine fish from the use of dispersants is included in Section 9.1.8, Potential Effects on Wildlife and Pros and Cons of Dispersant Use.

Marine currents, wind, and wave action would also cause dilution of a dispersant-oil mixture. Dilution occurs rapidly in the marine environment with strong current activity such as the PDA. Due to dilution, the potential for acute impacts from dispersed oil is limited in duration and space, and chronic exposure is not expected to be a significant factor in the overall risks posed to marine biota during a spill event. Undispersed oil generally has similar toxicity as most dispersant-oil mixtures and the use of dispersants in alignment with NEBA, as described in the OSRP, generally does not represent an additional risk to marine biota.

Adult fish may avoid an area affected by a spill, as they are not physiologically required to breathe at the surface where oil would accumulate. The early life stages of marine fish are most susceptible to the effects of a spill. During ichthyoplankton life stages, marine fish species are less able to avoid spilled oil, and the ichthyoplankton that come into contact with the spill would

[19] The U.S. Environmental Protection Agency classifies substances with LC50 values (concentration that will kill 50 percent of the test animals with a single exposure) of greater than 100 ppm as “practically nontoxic.”

experience high mortality rates. Pelagic species' habitat coincides with the portion of the water column that would be most affected by the spill. Pelagic species adults would have the ability to avoid areas affected by the spill. Demersal species would have only a limited exposure to the spill as the oil would rise through the water column and away from demersal species' bottom habitats. Accordingly, the intensity of such an impact is considered **Medium** for pelagic species and **Low** for demersal species.

The geographic extent of an unmitigated loss-of-well-control event would include portions of the **Indirect AOI**. On the basis that the impacts from an unmitigated marine oil spill would continue over several weeks, the frequency is considered to be **Continuous**. The effects, assuming no mitigation of the marine oil spill, would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large** for pelagic species and **Small** for demersal species. Consistent with the sensitivity ratings assigned for potential impacts on marine fish from planned activities, a sensitivity rating of **Low** is assigned for pelagic species and a sensitivity rating of **Medium** is assigned for demersal species.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium** for pelagic species and **Low** for demersal species. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a marine oil spill is considered **Unlikely**, so the overall risk of an unmitigated marine oil spill to marine fish is considered **Minor**.

Effective implementation of measures to stop the spill or contain it would reduce the geographic extent of the spill, and would reduce the amount of oil at the water's surface. If applied, dispersants would increase the concentrations of oil entrained in the upper portions of the water column and thus pelagic species' exposure to near-surface entrained oil. The NEBA process would optimize use of dispersant such that the benefits would be expected to outweigh the negative effects of increased concentrations of emulsified or entrained oil near the surface. Accordingly, the intensity of such an impact would be reduced to **Low** for pelagic species and would remain **Low** for demersal species. The geographic extent of a mitigated loss-of-well-control event would include portions of the **Indirect AOI**. On the basis that impacts from an unmitigated loss-of-well-control event could persist over several weeks, the frequency is considered to be **Continuous**. The effects, assuming mitigation of the spill, would be reduced to more than a week but less than a year, so duration would be reduced to **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium** for both pelagic and demersal species. Consistent with the sensitivity ratings assigned for potential impacts on marine fish from planned activities, a sensitivity rating of **Low** is assigned for pelagic species and a sensitivity rating of **Medium** is assigned for demersal species.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low** for pelagic and **Medium** for demersal species. As

described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a marine oil spill is considered **Unlikely**, so the overall risk of a marine oil spill to marine fish would remain **Minor**.

9.12.3. Coastal Fuel Spill

Although pelagic and coastal adult fish species tend to be resilient to the impacts of fuel spills, fish at all life stages can be substantially impacted in some circumstances, especially when fuel spills occur in shallow or confined waters such as the Demerara River. In exceptional circumstances, depletion of a year class for a particular species has been recorded, but mass fish mortalities as a result of a fuel spill are rare. Mass mortalities that have occurred have in some cases been associated with fuel spills in rivers (ITOPF 2014). If a spill were to occur in the Demerara River and penetrate the shallow creeks and lagoons within the mangroves, mortality of adult and subadult life stages could be much higher than for a comparable spill in the open ocean. Adult and subadult fish would have some ability to avoid the area affected by a spill, but this ability would be constrained within the confines of the lower Demerara River and early life stages that are less able to avoid affected areas would likely comprise a higher proportion of the community in the river than in the open ocean; accordingly, the intensity of such an impact is considered **High**.

The geographic extent of a coastal fuel spill would include the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spill weathers), and because the impacts of an unmitigated coastal fuel spill could—depending on volume of release—continue for several weeks, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Large**. Consistent with the sensitivity ratings assigned for potential impacts on marine fish from planned activities, a sensitivity rating of **Low** is assigned for pelagic species and a sensitivity rating of **Medium** is assigned for demersal species.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium** for pelagic species and **High** for demersal species.

As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a coastal fuel spill is considered **Unlikely**, so the overall risk of a coastal fuel spill to marine fish is considered to be **Minor** to **Moderate**. Effective implementation of the OSRP would reduce the geographic extent of the spill and, depending on the specific response strategies implemented in shallower waters, could reduce the amount of oil at the water's surface; accordingly, the residual risk rating would remain **Minor.**

9.12.4. Release of NADF

In the unlikely event of a release of NADF caused by an emergency riser disconnect due to DP station-keeping failure of a drill ship, lighter oil fractions would likely rise into the mid-water column and dissipate laterally as they rise, while the remaining heavier oil fractions of the NADF would remain at or near the seafloor. Such an event would expose fish in the middle water

depths within the PDA to low concentrations of dissolved light oils and expose deepwater-adapted fishes and benthos within the PDA to NADF. An NADF release would be expected to only temporarily affect a small area around the release point due to effective implementation of the OSRP. In consideration of these factors, the intensity of such an impact is considered **Low**.

The geographic extent of a release of NADF would include the **Direct AOI**. On the basis that impacts on marine fish from an unmitigated NADF release would persist as long as they were exposed to the spilled material, the frequency is considered to be **Continuous**. The effects of an NADF release would last less than a year, so duration would be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity ratings assigned for potential impacts on marine fish from planned activities, a sensitivity rating of **Low** is assigned for pelagic species and a sensitivity rating of **Medium** is assigned for demersal species.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low** for pelagic and demersal species.

As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a release of NADF is considered **Unlikely**, so the overall risk of a NADF release on marine fish is considered **Minor**. Response actions would focus on identifying and rectifying the condition that caused the release, and the residual risk would remain **Minor**.

9.12.5. Discharge of Untreated Wastewater from the FPSO

A discharge of untreated wastewater from the FPSO would only occur if equipment onboard the FPSO were to fail, and would involve the release of untreated wastewater directly overboard through an outfall. The untreated discharge would have localized impacts on water quality, but it is expected that the equipment would be repaired and marine currents would dilute the untreated wastewater within a short period of time. The primary constituents in wastewater would include solids and biodegradable organics, carbon, nutrients (primarily nitrogen and phosphorous), and pathogens, such as coliform. The affected area would likely be somewhat larger than the mixing zone associated with normal operations, but not large enough to cause a regionally significant event. As described in Section 9.1.11, Discharge of Untreated Wastewater from the FPSO, modeling results show that a release of untreated wastewater would result in a temporary plume of limited extent and that constituent concentrations would never exceed the end-of-pipe levels recommended by the IMO's 2012 *Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants* (IMO 2012).

Marine fish in the area at the time of the accidental release could be exposed to the wastewater plume by swimming through the plume and having it contact their skin and/or gills (i.e., dermal and respiratory contact). However, given the constituents and associated concentrations, the wastewater plume would not be expected to expose marine fish to significant toxicity effects (injury or mortality), nor would it be likely to induce hypoxia. Under specific conditions and concentrations, untreated wastewater discharge can harm marine organisms, especially in coastal waters with limited flow or water exchange (National Research Council 1993). An untreated wastewater discharge from the FPSO would occur in the open ocean and the

discharge would be expected to rapidly assimilate into the ocean, significantly limiting potential exposure of marine fish to the discharge.

The geographic extent of an accidental discharge of untreated wastewater from the FPSO would be limited to the **Direct AOI**. Using the definitions established for assessment of potential impact on marine fish from planned Project activities, the intensity of potential impacts of a discharge of untreated wastewater from the FPSO is considered **Negligible**. The frequency of a discharge of untreated wastewater from the FPSO would be **Episodic** because, if it were to occur, it would occur infrequently. The duration of this impact would be **Short-term**, as the discharge would assimilate into the ocean quickly. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible**.

Using the definitions established for assessment of potential impacts on marine fish from planned Project activities, and considering that exposure to impacts from a release of untreated wastewater from the FPSO would be limited to pelagic fish, the sensitivity of marine fish to impacts from a discharge of untreated wastewater from the FPSO is considered **Low**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**. Multiple redundancies in the FPSO's wastewater management system would have to fail simultaneously for untreated wastewater to be released to the environment; therefore, such an event is considered **Unlikely**. These factors yield a pre-mitigation risk rating to marine fish from a discharge of untreated wastewater from the FPSO of **Minor** (see Table 9.12-1). Response actions would focus on identifying and rectifying the condition that caused the release rather than recovery of discharged material, and the residual risk would therefore be retained at **Minor**.

Table 9.12-1: Risk Ratings for Unplanned Event Impacts on Marine Fish

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Fish	Unlikely	Medium	Minor	Implement OSRP	Minor
Coastal Fuel Spill	Marine Fish	Unlikely	High	Minor to Moderate	Implement OSRP	Minor
NADF Release	Marine Fish	Unlikely	Low	Minor	Implement OSRP	Minor
Discharge of Untreated Wastewater from the FPSO	Marine Fish	Unlikely	Low	Minor	None	Minor

9.13. MARINE BENTHOS

As indicated in Table 9.1-6, the only unplanned events with the potential for any measurable impacts on marine benthos would be a marine oil spill, coastal fuel spill, and an NADF release.

9.13.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Tables 7.9-5 and 7.9-6 in Section 7.9, Marine Benthos, contain the definitions for intensity of impact and sensitivity of receptor, respectively, for impacts on marine benthos.

9.13.2. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, stochastic oil spill modeling for the Most Credible WCD and Maximum WCD scenarios indicates a 5 to 40 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 1 and a 5 to 10 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 2. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain offshore of Guyana for the Most Credible WCD scenario and for the Maximum WCD (Jun–Nov) scenario. Deterministic modeling predicts impact across the majority of the Region 1 shoreline for the (Dec–May) Maximum WCD scenario. Modeling mitigation under this scenario predicts a reduction in the predicted length of shoreline impact in Region 1, but the predicted length still represents the majority of the Region 1 shoreline. The deterministic modeling analysis does not predict shoreline impacts in Guyana outside of Region 1 for either the Most Credible WCD or Maximum WCD scenarios, regardless of season or the effects of mitigation. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

Most of the oil released from a marine oil spill would be expected to rapidly travel to the surface, but a limited amount of oil may bind with sediments in the water column and settle to the bottom, which could expose benthic organisms to toxic constituents. After the Deepwater Horizon oil spill, low taxa richness and high nematode/harpacticoid-copepod ratios, which are indicative of contamination, were found in areas within about 3 kilometers (1.8 miles) of the wellhead (Montagna et al. 2013). These impacts were considered to have resulted from attempts to regain well control by injecting drilling fluids into the open wellhead rather than the loss-of-well-control event and resulting oil spill itself. Polychaete worms, of the most diverse and frequently observed benthic taxa in the Stabroek Block, have varied responses to oil pollution. After an initial die-off, some disturbance- and pollution-tolerant polychaete species may increase in abundance and rapidly colonize damaged habitat, while other species, particularly crustaceans and mollusks, may experience reduced populations (Blackburn et al. 2014; Fisher et al. 2014).

As described in Section 9.3, Marine Geology and Sediments, evidence from the Deepwater Horizon incident (Reuscher et al. 2020) documented an increase in settlement of released hydrocarbons through adhesion to falling organic detritus made up of plankton, bacteria, fecal matter, etc. (i.e., “marine snow”) and concomitant contamination of marine sediments. The spill’s stress on the plankton can stimulate production of sticky mucous, further increasing the proclivity of the oil to adhere to the marine snow (Joye et al. 2016). In the case of the Deepwater Horizon incident, settled hydrocarbons were observed more than 200 kilometers (124.3 miles) away from the source, having covered the seafloor beneath the moving surface slick. While the area of these marine snow deposits was observed over 200 kilometers (124.3 miles) from the wellhead (Brooks et al. 2015), the region with moderate to severe impacts on the benthos was

more localized to a 263-square-kilometer (101.6-square-mile) area mostly around the wellhead (Reuscher et al. 2020). See additional discussion in Section 9.3 related to increased sedimentation due to oil adhered to oil contaminated marine snow during a marine oil spill event. Using the definitions presented in Table 7.9-5, the intensity of potential impacts of an unmitigated marine oil spill on marine benthos is considered as high as **Medium** assuming the presence of sufficient sticky marine snow substrate to transfer the oil to the seafloor. The geographic extent of an unmitigated loss-of-well-control event could encompass portions of the **Indirect AOI**. On the basis that impacts on marine benthos from an unmitigated loss-of-well-control event would persist as long as the spill remained unmitigated, the frequency is considered to be **Continuous**. Without mitigation, marine benthos would gradually recover to some extent—depending on the degree of oil exposure at the seafloor—but impacts could still persist beyond a year, yielding a **Long-term** duration. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**.

The same considerations regarding sensitivity to contamination from cuttings deposition discussed in Section 7.9, Marine Benthos, also apply to contamination from oil released during a spill event (i.e., oil deposited on the seafloor can pose risks to those deep-sea benthos living within or in close association to bottom substrates that are unable to avoid exposure due to their relatively sedentary existence). These effects would be contained within the area that oil would settle; but as discussed above, this area could be larger than the area affected by cuttings deposition. Consequently, impacts on a portion of the benthic community due to oiling of the seafloor could affect a larger proportion of the broader Stabroek Block benthic community and warrants a sensitivity rating of **Medium.** Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the pre-mitigation risk to marine benthos is considered **Moderate**.

Although there is little in the way of mitigation that would further reduce the potential impacts of a marine oil spill on marine benthos in proximity to the well, EEPGL has a number of embedded controls to prevent a spill from occurring, and implementation of the OSRP would reduce the level of impact if a spill were to occur. However, despite this reduction and with the inclusion of dispersants applied during mitigation (which could reduce the surface slick area, volume, and duration of the spill, but could also promote plankton mucous production (Joye et al. 2016), thereby increasing sediment contamination), the intensity of potential impacts on marine benthos from a mitigated marine oil spill would likely remain **High**. The duration would likely be reduced to no more than **Medium-term**. This reduces the magnitude rating to **Medium** and the consequence/severity rating to **Medium**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall residual risk to marine benthos from a mitigated marine oil spill would be reduced to **Minor** (see Table 9.13-1).

9.13.3. Coastal Fuel Spill

Modeling indicates that an unmitigated coastal fuel spill would likely only happen near a shorebase or near the mouth of the Demerara River. Limited information is available describing

the marine benthos near the mouth of the Demerara River; however, based on historical and ongoing human activities in this area, the existing benthic community in this area is likely comprised of disturbance-tolerant benthic species. Coastal spills would be quickly controlled and contained because of the relatively small volume of the spill and the ready access to spill control equipment. A coastal spill would thus be short-lived and limited in area and volume of oil released, with rapid recovery of any affected benthos expected. Spilled fuel would not sink or accumulate on the seafloor unless adsorption occurs with suspended sediment or at the coastline, especially in the intertidal zones; however, it is possible for fuel that is dispersed by wave action to form droplets that are small enough to be kept in suspension and moved by the currents. The oil dispersed in the water column, and dissolved components of that oil, can adhere to fine-grained suspended sediments, which can settle out and deposit on the seafloor. This is less likely to occur in open marine settings and is not likely to result in measurable sediment contamination for small spills (NOAA 2020).

Accordingly, the intensity of such an impact on benthos, if it were to occur, would be considered **Low**. The geographic extent of an unmitigated coastal fuel spill event could potentially include portions of the **Indirect AOI**, assuming the spill is large enough to migrate outside of the Project transit corridor. On the basis that impacts on coastal habitats would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled fuel weathers), and because the impacts of an unmitigated coastal fuel spill could—depending on volume of material release—continue over several weeks, the frequency and duration are considered to be **Continuous**, and **Medium-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude of **Medium**. Using the definitions for sensitivity rating presented in the assessment of potential impacts on benthos from planned Project activities, a sensitivity rating of **Low** is assigned. Therefore, applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a coastal fuel spill is considered **Unlikely**, so the overall risk to benthos from a coastal fuel spill would be **Minor** (see Table 9.13-1).

9.13.4. Release of NADF

Marine benthos would be the most sensitive of all the marine biological resources/receptors to an unplanned release of NADF from an emergency riser disconnect and loss of DP on a drill ship due to their close proximity to the release point and the tendency of the NADF and cuttings plume to remain at or near the seafloor. In addition, marine benthos have limited mobility to move away from the impacted area compared to other marine organisms. However, the material discharged would be limited in volume (i.e., limited to the volume of the riser), with a release that would be short-term, and have low-toxicity (containing IOGP Group III NADF, with low to negligible aromatic content).

A review of potential impacts of NADF and cutting deposition on marine benthos indicates marine benthos would not only be buried, but sediment texture would be altered, and water quality would deteriorate leading to hypoxia (IOGP 2016). The smaller and less mobile

organisms (burrowing species, worms, and immobile lifeforms [sponges, bryozoans, gorgonians, and most mollusks]) would generally be affected to a greater degree than larger and more mobile species that would have the ability to move away from impacted areas (e.g., large crustaceans, cephalopods).

As described in Sections 9.3, Marine Geology and Sediments, and 9.4, Marine Water Quality, marine currents in the Project AOI would reduce the potential for burial of benthos and the formation of hypoxic zones within the sediment. When such events occur, recovery through natural recruitment from adjacent undisturbed areas is typically well underway within a year of the impact having occurred, but the potential does exist for short-term impacts on marine benthos in the unlikely event of a release, and such an event would likely cause at least a temporary decrease in both the abundance and diversity of marine benthos within the deposition zone.

Using the definitions in Table 7.9-5, the intensity of potential impacts of an NADF release on marine benthos is considered **Low**. The geographic extent of an unmitigated NADF release would be limited to the **Direct AOI**. On the basis that impacts on marine benthos from an unmitigated NADF release would persist as long as they were exposed to the spilled material, the frequency is considered to be **Continuous**. Even without mitigation, marine benthos would gradually recover to some extent, and the currents would redistribute the spilled material and impacts would be expected to persist less than a year, yielding a **Medium-term** duration. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**.

The same considerations regarding sensitivity to contamination from cuttings deposition discussed in Section 7.9, Marine Benthos, also apply to contamination from a release of NADF. Similar to the effects of cuttings deposition, the small volume of NADF would limit the area exposed to impacts. A small fraction of the overall benthic community would be exposed to these impacts, and the sensitivity of the community as a whole would be exposed to potential impacts of an NADF release, so the overall sensitivity of marine benthos is rated as **Low**. Therefore, applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. In combination with a likelihood rating of **Unlikely** for an accidental NADF release, the overall risk to marine benthos from an accidental NADF release would be **Minor** (see Table 9.13-1).

A mitigated release of NADF would be smaller in volume and the impacts would be shorter in duration than the unmitigated scenario described above, yielding an intensity rating of **Negligible** for all scenarios considered. This leads to a magnitude rating of **Negligible** and a consequence/severity rating of **Low**. In combination with a likelihood rating of **Unlikely** for the accidental release of NADF, the overall residual risk to marine benthos from a mitigated release of NADF would be **Minor** (see Table 9.13-1).

Table 9.13-1: Risk Ratings for Unplanned Event Impacts on Marine Benthos

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Benthos	Unlikely	High	Moderate	Implement OSRP	Minor
Coastal Fuel Spill	Marine Benthos	Unlikely	Low	Minor	Implement OSRP	Minor
NADF Release	Marine Benthos	Unlikely	Low	Minor	Implement OSRP	Minor

9.14. ECOLOGICAL BALANCE AND ECOSYSTEMS

As indicated in Table 9.1-6, the unplanned events with the potential for measurable impacts on ecological balance and ecosystems include a marine oil spill, a coastal fuel spill, a release of NADF, and a discharge of untreated wastewater from the FPSO.

9.14.1. Definitions for Intensity of Impact and Sensitivity of Receptor

Tables 7.10-2 and 7.10-4 in Section 7.10, Ecobalance and Ecosystems, contain the definitions for intensity of impact and sensitivity of receptor, respectively, for impacts on ecological balance and ecosystems.

9.14.2. Marine Oil Spill

9.14.2.1. Impacts on the Marine Nutrient Cycle

Impacts on the marine nutrient cycle from a marine oil spill would be determined by the impact of the spill on phytoplankton. The available literature suggests that toxicological impacts of oil on phytoplankton vary widely according to nutrient content of the water, temperature, type of oil, and exposure (Wang et al. 2008; Ozhan et al. 2014; Tang et al. 2019). A persistent, heavy surface slick has the potential to reduce gas exchange and light transmission at the water's surface, which generally reduces photosynthetic activity and primary productivity in the impacted area (Ozhan et al. 2014). Reduced cellular activity in the phytoplankton would reduce the uptake of nutrients (nitrogen, phosphorous, and silicates) into the base of the aquatic food web.

As described in Section 9.1.5, Oil Spill Modeling Results, stochastic oil spill modeling for the Most Credible WCD and Maximum WCD scenarios indicates a 5 to 40 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 1 and a 5 to 10 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 2. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain offshore of Guyana for the Most Credible WCD scenario and for the Maximum WCD (Jun–Nov) scenario. Deterministic modeling predicts impact across the majority of the Region 1 shoreline for the (Dec–May) Maximum WCD scenario. Modeling mitigation under this scenario predicts a reduction in the predicted length of shoreline impact in Region 1, but the predicted length still represents the majority of the Region 1 shoreline. The deterministic modeling analysis does not predict shoreline impacts in Guyana

outside of Region 1 for either the Most Credible WCD or Maximum WCD scenarios, regardless of season or the effects of mitigation.

Deterministic modeling predicts that in the case of an unmitigated spill, surface concentrations of oil would remain beyond 45 days following initial release, but the area of ocean with oil at the surface would change as the oil gradually moves north and west away from the location of the spill and not all portions of the area swept by a spill would contain oil on a continuous basis throughout the modeled period. Deterministic modeling of mitigated spills in both the Most Credible WCD and Maximum WCD scenarios predicts there will be no remaining surface oil, or very little in the case of winter spills, within 6 to 10 days following the initial release (RPS 2021). As the slick breaks up and thins, light transmission would be restored, and the plankton community would be replenished by plankton carried into the Project AOI by the Guiana Current from unaffected areas to the east. Based on the deterministic modeling results, impacts to phytoplankton populations would be expected to be short-lived and extend over a more limited area than in an unmitigated spill scenario. Due to phytoplankton's short generation times relative to those of other marine taxa (Muller-Karger and Castro 1994; NRC 2003) and the influx of unaffected plankton from the southeast via the Guiana Current, once surface oils are below thresholds that are toxic to phytoplankton, phytoplankton communities would be expected to recover quickly.

Several studies have documented post-spill shifts in feeding behavior in birds and fish, but studies of spill-related impacts on other marine taxa are generally lacking. Most studies cite short-term adjustments in feeding strategies by birds or fish following a spill, but many cite the need for longer-term study to document the role of spills in these shifts or an inability to identify hydrocarbon contamination as a driving factor due to confounding environmental impacts, or both (Snyder et al. 2015; GOMRI 2015; Piatt and Anderson 1996). Post-spill recovery of ecosystems may be influenced by the presence of invasive species such as the lionfish (*Pterois* spp.) (Lewis et al. 2020). Studies that successfully control for such factors and purport to document a causal relationship between oil spills and trophic shifts typically document a shift back to pre-spill conditions that varies from a few years to five or more years (Lewis et al. 2020; Moreno et al. 2013; GOMRI 2015).

A large marine oil spill could have ecosystem-level trophic level impacts if hydrocarbons persist in the food web and have toxic impacts on organisms, or if underlying changes in abundance or distribution of prey cause shifts in feeding behavior or effectiveness in upper trophic levels. Although the assimilation of hydrocarbons into living tissues is well established at multiple trophic levels (Teal and Howarth 1984; Neff 2002; Chanton et al. 2012; GOMRI 2015), there has been no conclusive documentation of biomagnification of hydrocarbons up the food chain following a major oil spill. Researchers conducting studies on fish following oil spills have documented the residence of PAHs in fatty tissues, but that fish and other higher vertebrates are able to dispose of the hydrocarbons through metabolic means. The ability to metabolize hydrocarbons and the length of time it takes to metabolize the hydrocarbons varies by species (Law et al. 1997; Neff 2002; Jung et al. 2011). Law et al. (1997) reported that PAH levels returned to normal (i.e., baseline) within 4 months for finfish and 6 months for bivalve mollusks after the Sea Empress oil spill in Pembrokeshire, Wales in 1996.

9.14.2.2. Impacts on Gene Flow

As described in Section 7.10.3, Impact Assessment—Ecological Balance and Ecosystems, obstacles to efficient gene flow occur when physiochemical barriers prevent organisms from migration, breeding, or dispersal/colonization. A mitigated marine oil spill could cause a short-term physiochemical barrier to migration through the Project AOI, although the significance of this barrier impact would vary across species and seasons. Impacts on gene flow in marine fish would be negligible, because there are no known sensitive spawning aggregations or habitat that would support such aggregations in the PDA or in the vicinity of the Project AOI. Non-mobile organisms (e.g., benthic species) are more vulnerable to gene flow impacts (oceanographic discontinuities) than highly mobile animals (pelagic highly migratory fish) (Pascual et al. 2017). Most marine animals in the upper water column of the Project AOI are mobile. Marine mammals would also be expected to avoid the impacted area, although in the initial stages of a spill they could be impacted to a greater degree than the fish (e.g., if they inhaled vapors or oil at the surface prior to vacating the area). Marine turtles and seabirds would be more sensitive to indirect impacts on gene flow derived from reduced breeding success because they do congregate to nest in portions of the Project AOI (see Sections 9.8, Seabirds, and Section 9.11, Marine Turtles).

9.14.2.3. Impacts on Biodiversity

A marine oil spill has the potential to cause a short-term decline in biodiversity depending on spill volume and pre-spill ecological community conditions (Tansel 2014). Some species may exhibit avoidance behavior, and sensitive species that remain in the area may experience localized population declines or a reduction in vigor. As described above, surface oil is predicted to travel toward the northwest in all scenarios during both the summer and winter seasons. Oil would remain in at least some portions of the ocean over the entire simulated period of 45 days, although not all portions of the swept area would contain oil for entire simulated period.

The Region 1 coastline contains the SBPA with coastal habitats including mangrove forest, tidal and brackish wetlands, and sand beach, and would be vulnerable to exposure to an oil spill because of their physical location adjacent to the surf zone. These habitats in the coastal margin not only provide critical nursery and feeding to a variety of estuarine and marine organisms, but damage from oiling in these areas could potentially degrade ecosystem services they provide and impact their economic and environmental importance (Murawski et al. 2021). These modeling results indicate that even with mitigation, potential impacts from WCD events would encompass a large geographical footprint, including large expanses of marine, coastal, and nearshore ecosystems.

9.14.2.4. Overview of Impacts on Ecological Balance and Ecosystems from a Marine Oil Spill

Using the definitions presented in Table 7.10-2, the intensity of potential impacts of an unmitigated marine oil spill on ecological balance and ecosystems is considered **Medium**. This rating is based on the range of ecological receptors that could be affected, their different tolerances for spill-related impacts, the numerous interdependencies between the biological and

physical elements of the marine ecosystem, and the variety of induced and indirect impacts that those interdependencies create. The geographic extent of an unmitigated loss-of-well-control event could encompass portions of the **Indirect AOI**. On the basis that impacts on ecological balance and ecosystems from an unmitigated loss-of-well-control event would persist as long as the spill remained unmitigated, the frequency is considered to be **Continuous**. Even without mitigation, ecological balance and ecosystems would gradually recover to some extent—depending on the degree of oil exposure—but impacts could still persist beyond a year, yielding a **Long-term** duration. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**.

Based on the sensitivity rating definitions presented in Table 7.10-4, the receptor sensitivity for ecological balance and ecosystems is considered **Low** for impacts on nutrient cycling and gene flow, and **Medium** for impacts on biodiversity. The **Low** sensitivity rating for nutrient cycling and gene flow are principally due to the assimilative capacity of the Large Marine Ecosystem (LME) afforded by its large size, and the assumption that genetic exchange between the North Brazil LME and adjacent LMEs is robust due to the general lack of obstacles to gene flow in the ocean. The **Medium** sensitivity rating for impacts on biodiversity is principally due to the numerous species in the LME with elevated conservation status.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Medium** to **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the pre-mitigation risk to ecological balance and ecosystems is considered **Minor** to **Moderate**.

EEPGL has a number of embedded controls to prevent a spill from occurring as described in Chapter 2, Description of the Project, and implementation of the OSRP would reduce the level of impact if a spill were to occur. With this reduction, the intensity of potential impacts on ecological balance and ecosystems from a mitigated marine oil spill would be **Low**. The duration would likely be reduced to no more than **Medium-term**. This reduces the magnitude rating to **Medium** and the consequence/severity rating to **Low** to **Medium**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall residual risk to ecological balance and ecosystems from a mitigated marine oil spill would be **Minor** (see Table 9.14-1).

9.14.3. Coastal Fuel Spill

9.14.3.1. Impacts on the Marine Nutrient Cycle

The impacts on the nutrient cycle from a coastal fuel spill would be similar to the impacts of a marine oil spill in the sense that they would be largely controlled by the nature of the spill's impact on phytoplankton and primary production rates. However, the types of phytoplankton and their sensitivity to a fuel spill are expected to be different in the lower Demerara River than offshore. The effects on light transmission from a fuel spill at the water's surface is expected to be much less significant in regulating primary production in the Demerara River than offshore or the nearshore environment, because turbid conditions in the river naturally limit light transmission in the river. This would imply a greater phytoplankton resilience to fuel spills in the

river than offshore. However, to the extent that phytoplankton in the river would be impacted by toxicological effects or reduced gas exchange, they may not be as easily replaced from surrounding populations, as they would be in the open ocean. Therefore, fuel-spill induced reductions in primary productivity may be lower in the river than in the ocean, but the nutrient cycle in the river may also be slower to recover.

9.14.3.2. Impacts on Gene Flow

A coastal fuel spill could cause a physiochemical barrier to migration of coastal and riverine organisms that rely on passage to and from the lower Demerara River for migration, feeding, breeding, or dispersal/colonization. The significance of this impact would vary across species and seasons. One of the most sensitive groups of organisms to this effect would include species that use the lower river as nursery habitat on a seasonal basis, such as crustaceans and fish. Impacts would be more severe during and immediately following spawning seasons, when entire year classes of juvenile fish and crustaceans, with limited mobility, occur in large numbers in this area. Impacts would likely be less in non-spawning seasons.

9.14.3.3. Impacts on Biodiversity

Impacts on biodiversity from a coastal fuel spill in or near the Demerara River would be similar in terms of their mechanisms, but would affect different species. A coastal fuel spill would likely affect more species of birds, more riverine mammals, fewer marine mammals, and different species of fish than a marine fuel spill, and would have little or no impact on marine turtles. As previously discussed, some species groups such as marine mammals and marine fish, may be able to avoid the effects of a spill within the river. Coastal birds and shorebirds that forage in the river and along its shores probably would not be as readily able to avoid a spill's effects because their foraging areas are defined by water depth, tides, and other factors that would not change in response to a spill event.

9.14.3.4. Overview of Impacts on Ecological Balance and Ecosystems from a Coastal Fuel Spill

Using the definitions presented in Table 7.10-2, the intensity of potential impacts of an unmitigated coastal fuel spill on ecological balance and ecosystems is considered **Medium**. This rating is based on the range of ecological receptors that could be affected, their different tolerances for spill-related impacts, the numerous interdependencies between the biological and physical elements of the marine ecosystem, and the variety of induced and indirect impacts that those interdependencies create. The geographic extent of an unmitigated coastal fuel spill would be limited to the **Indirect AOI**. On the basis that impacts on ecological balance and ecosystems from an unmitigated coastal fuel spill would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the fuel spill weathers), and because the impacts of an unmitigated coastal fuel spill could—depending on volume of release—continue over several weeks, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4,

Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Medium**.

Based on the sensitivity rating definitions presented in Table 7.10-4, the receptor sensitivity for ecological balance and ecosystems is considered **Low** for impacts on nutrient cycling and gene flow, and **Medium** for impacts on biodiversity.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low** to **Medium**. In combination with a likelihood rating of **Unlikely** for a coastal fuel spill, the pre-mitigation risk to ecological balance and ecosystems is considered **Minor**.

EEPGL has a number of embedded controls to prevent a spill from occurring, and implementation of the OSRP would reduce the level of impact if a spill were to occur. With this reduction, the intensity of potential impacts on ecological balance and ecosystems from a mitigated coastal fuel spill would likely be **Low**. The duration would likely be reduced to no more than **Medium-term**. This reduces the magnitude rating to **Small** and the consequence/severity rating to **Low**. In combination with a likelihood rating of **Unlikely** for a coastal fuel spill, the overall residual risk to ecological balance and ecosystems from a mitigated coastal fuel spill would be **Minor** (see Table 9.14-1).

9.14.4. Release of NADF

9.14.4.1. Impacts on the Marine Nutrient Cycle

Deep-sea foodwebs are highly dependent on inputs from the upper portions of the water column such as marine snow[20] and other larger detrital inputs (e.g., carcasses of larger animals) (Armengol et al. 2019). A release of NADF would have no effect on the rate at which these nutrient inputs reach the deep ocean and would have too short a duration to significantly affect the rate at which they would be consumed, so a release of NADF would have little if any effect on marine nutrient cycling. Release of NADF near the seafloor would enrich the nutrient content of the marine sediment down current of the affected wellhead due to the presence of biodegradable organic material in the fluid. This enrichment could temporarily shift the food chain as the makeup of the marine benthos changes, but it is unlikely that these changes in the benthic community would cause substantial changes in upper trophic levels.

9.14.4.2. Impacts on Gene Flow

A release of NADF would mostly affect benthic biota and deepwater/midwater fishes. Empirical data on the rates of genetic exchange in these communities are scarce (Aslan et al. 2019). Based on the similarities in the benthic communities within the Stabroek Block as discussed in Section 7.9.2.3, Existing Conditions in the Project Development Area, the area of seafloor that could be affected by an NADF release is unlikely to contain genetically distinct populations of benthos or demersal fish. Therefore, in the event that an NADF release were to temporarily

[20] Fine biological debris and other organic material that descend from upper portions of the water column to the deep ocean

cause localized mortality or reduced reproduction, the area would likely be recolonized by organisms with a similar genetic composition as the affected population.

9.14.4.3. Impacts on Biodiversity

As discussed in previous sections, exposure to the impacts of a release of NADF would largely be limited to benthos and fish, and these impacts would be temporally and spatially limited. Considering that benthos and fish communities would be expected to recover rapidly from the effects of an NADF release, an NADF release would not pose a significant risk to biodiversity.

9.14.4.4. Overview of Impacts on Ecological Balance and Ecosystems from an NADF Release

A release of NADF would have little to no lasting effect on nutrient cycles, gene flow, or biodiversity (Garcia et al. 2014). Based on the definitions presented in Table 7.10-2, the intensity of the impact of an NADF release on ecological balance and ecosystems is considered **Low**. The geographic extent of an unmitigated NADF release would be limited to the **Direct AOI**. On the basis that impacts on ecological balance and ecosystems from an unmitigated NADF release would persist as long as ecological receptors were exposed to the spilled material, the frequency is considered to be **Continuous**. Even without mitigation, ecological balance and ecosystems would gradually recover to some extent, and the currents would redistribute the spilled material and impacts would be expected to persist less than a year, yielding a **Medium-term** duration. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**.

Coupled with the sensitivity rating of **Low** to **Medium** for nutrient cycling/gene flow and biodiversity, respectively, the consequence/severity of such a release on ecological balance and ecosystems would be **Low**. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a release of NADF is considered **Unlikely**, so the overall risk of a NADF release to ecological balance and ecosystems is considered **Minor**. Response actions would focus on identifying and rectifying the condition that caused the release and the residual risk would be **Minor** (see Table 9.14-1).

9.14.5. Discharge of Untreated Wastewater from the FPSO

9.14.5.1. Impacts on the Marine Nutrient Cycle

A release of untreated wastewater from the FPSO would enrich the nutrient content of the marine water column down current of the FPSO due to the presence of biodegradable organic material in the discharge. This would have the effect of temporarily expanding the area of higher concentration adjacent to the FPSO, and if it persisted, could cause localized hypoxia within the expanded mixing zone. This enrichment could temporarily shift the food chain as the composition of the marine plankton community changes, but the effects of a wastewater release would not be expected to persist long enough to cause trophic impacts. Modeling analysis of an untreated black water discharge indicates that by 3 hours after the cessation of the discharge,

coliform concentration would decrease to less than 1 colony forming unit per 100 milliliters[21] (see Appendix C, Water Quality Modeling Report). Using coliform concentrations as a proxy for other constituents in the discharge, the modeling results indicate that the effects of a release of untreated wastewater would be very short term.

9.14.5.2. Impacts on Gene Flow

A discharge of untreated wastewater from the FPSO could cause the more sensitive organisms in the immediate vicinity of the FPSO to vacate the expanded zone of higher concentration temporarily. However, as discussed above, currents would dilute untreated wastewater in a few hours and the temporary effects would not persist long enough to affect reproductive cycles. Similar to the impacts described above in the discussion of the effects of an NADF release, the zone of higher concentration that would form as a result of an untreated wastewater discharge from the FPSO is unlikely to contain genetically distinct populations. Therefore, in the event such a discharge were to temporarily cause localized mortality or reduced reproduction, the area would probably be recolonized by organisms with a similar genetic composition as the affected population.

9.14.5.3. Impacts on Biodiversity

Impacts from a discharge of untreated wastewater from the FPSO would be temporally and spatially limited. Considering that benthos and fish communities would be expected to recover rapidly from the effects of such a release as described in previous sections, this event would not pose a significant risk to biodiversity.

9.14.5.4. Overview of Impacts on Ecological Balance and Ecosystems from Discharges of Untreated FPSO Wastewater

A discharge of untreated wastewater from the FPSO would have little to no long-term effect on nutrient cycles, gene flow, or biodiversity, so the intensity of the impact of the discharge on ecological balance and ecosystems is considered **Low**. The geographic extent of a discharge of untreated FPSO wastewater would be limited to the **Direct AOI**. Releases of untreated discharges from the FPSO would be **Episodic** and impacts would have a **Short-term** duration. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible**.

Coupled with the sensitivity rating of **Low** to **Medium**, the consequence/severity of such a release on ecological balance and ecosystems would be **Low**. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a release of untreated wastewater discharges from the FPSO is considered **Unlikely**, so the overall risk of discharges of untreated FPSO wastewater to ecological balance and ecosystems is considered **Minor**. Response actions would focus on identifying and rectifying the condition that caused the release and the residual risk would be **Minor** (see Table 9.14-1).

[21] The relevant IMO standard for fecal coliform is 100 colony-forming units per 100 milliliters.

Table 9.14-1: Risk Ratings for Unplanned Event Impacts on Ecological Balance and Ecosystems

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Ecological Balance and Ecosystems	Unlikely	Medium to High	Minor to Moderate	Implement OSRP	Minor
Coastal Fuel Spill	Ecological Balance and Ecosystems	Unlikely	Low to Medium	Minor	Implement OSRP	Minor
NADF Release	Ecological Balance and Ecosystems	Unlikely	Low	Minor	Implement OSRP	Minor
Untreated FPSO Wastewater Discharge	Ecological Balance and Ecosystems	Unlikely	Low	Minor	None	Minor

9.15. SOCIOECONOMIC CONDITIONS / EMPLOYMENT AND LIVELIHOODS

As indicated in Table 9.1-6, the unplanned events with the potential to result in measurable impacts on socioeconomic conditions or employment and livelihoods in the Project AOI would be a marine oil spill, a coastal fuel spill, and a collision between a Project vessel and a non-Project vessel. Oil or fuel spills could result in decreased fishery and/or coastal agricultural yields and could potentially impact the fishery and agriculture sectors that currently account for a large part of the country's gross domestic product. A vessel collision could result in damage to a vessel used for fishing or other commercial/subsistence purposes, leading to an impact on income or livelihood for the affected individual(s).

The economies in Regions 1, 2, 3, 5, and 6 are highly dependent on fishing and agriculture for employment, income generation, and subsistence. Although the economy in Region 4 is comparatively more diversified, populations in the rural areas also rely on agriculture and fishing, and this region accounts for a significant number of fisherfolk and some of the largest landing sites in the country. These economies would be sensitive to impacts on fisheries and coastal crop production that could result from an oil or fuel spill if it were to reach near-coastal waters or the coast. Impacts of an oil or fuel spill on river and coastal transportation networks that link communities and provide access to markets could also affect economies, especially in Region 1 and between Regions 2 and 3, where aquatic transportation is the only method of transportation available. These potential impacts are discussed below.

9.15.1. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, stochastic oil spill modeling for the Most Credible WCD and Maximum WCD scenarios indicates a 5 to 40 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 1 and a 5 to 10 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 2. Deterministic oil spill modeling

predicts that an unmitigated oil spill would remain offshore of Guyana for the Most Credible WCD scenario and for the Maximum WCD (Jun-Nov) scenario. Deterministic modeling predicts impact across the majority of the Region 1 shoreline for the (Dec–May) Maximum WCD scenario. Modeling mitigation under this scenario predicts a reduction in the predicted length of shoreline impact in Region 1, but the predicted length still represents the majority of the Region 1 shoreline. The deterministic modeling analysis does not predict shoreline impacts in Guyana outside of Region 1 for either the Most Credible WCD or Maximum WCD scenarios, regardless of season or the effects of mitigation.

Fisheries could be impacted by an unmitigated marine oil spill, especially if the oil reaches near-coastal waters, where most artisanal and commercial fishing occurs. Potential impacts on mangrove habitats could impact fishery nursery grounds and future-year class populations. Adult fish, however, are relatively resilient to oil spills because they are mobile and can quickly relocate away from an oil spill (see Section 9.12, Marine Fish). Deep-sea tuna fishing, which occurs at a small scale (12 Guyanese vessels in operation) in deep-sea waters, could also be affected. Fisheries may be impacted by any reduction in fish populations or closure of active fishing areas to allow for clean up or to avoid potential public health impacts, or as a result of actual or perceived tainting of commercial fish products. In the unlikely event of an unmitigated marine oil spill, there would be several days' advance notice before any oil would possibly reach the Guyana coast, so fisherfolk would have ample time to move their boats to unaffected alternate fishing areas.

9.15.1.1. Risk to Commercial and Artisanal Fishing

The intensity of an unmitigated marine oil spill impacting commercial and artisanal fisherfolk and other economic users of marine waters is considered **High**. This is based on the importance of the fishing industry to the economy of the Guyanese coastal populations. The geographic extent of an unmitigated marine oil spill would include portions of the **Indirect AOI**. On the basis that impacts from an unmitigated marine oil spill would continue over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming no mitigation of the marine oil spill, would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**. Consistent with the sensitivity ratings assigned for socioeconomic impacts from planned events on individuals and households within Region 4 (which can be more economically diverse) and those of lower socioeconomic status in other regions, a sensitivity rating of **Medium** to **High** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. As described above, a marine oil spill is considered **Unlikely**. Therefore, the pre-mitigation risk to fisherfolk is considered **Moderate**.

In the event of a marine oil spill, EEPGL would deploy emergency response equipment to mitigate the effects of the spill, and to protect sensitive coastal resources such as mangroves, as appropriate. Accordingly, considering effective implementation of the OSRP, the intensity of

such an impact would be reduced to **Medium**. The geographic extent of a mitigated marine oil spill would still include portions of the **Indirect AOI**, although the area affected would be substantially reduced with mitigation. On the basis that the impacts from a mitigated marine oil spill could persist over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming mitigation of the spill, would be reduced to more than a week but less than a year, so duration is considered to be **Medium-term**. Additionally, a claims process and, as appropriate, a livelihood remediation program (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established at the onset of a marine oil spill of sufficient magnitude to affect livelihoods of fisherfolk or other affected stakeholders (e.g., should mobility of transport and access to markets via aquatic networks be impacted). Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

A mitigated spill would be confined to waters further offshore than artisanal fisherfolk operate in Guyana, so the fisherfolk operating in the vicinity of a mitigated oil spill would likely be limited to commercial fisherfolk. In any case, both commercial and artisanal fisherfolk are assigned a sensitivity rating of **Medium** for planned impacts on employment and livelihood.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a marine oil spill is considered **Unlikely**. Therefore, the residual risk to socioeconomic conditions and employment and livelihood from this type of unplanned event is reduced to **Minor** (see Table 9.15-1).

9.15.1.2. Risk to Coastal Agriculture

Modeling results indicate that an unmitigated oil spill could reach the Guyana shoreline in Region 1 and/or Region 2, depending on wind and current conditions at the time of the spill. As discussed in Section 9.21, Land Use, in the unlikely event that oil spill impacts reach the coast the potential exists for subsistence farming along the SBPA in Region 1, and at various locations along the coast in Region 2, to be impacted (see Section 9.21, Land Use). A marine oil spill would only directly affect these areas if it was sufficiently large enough to reach these areas along the shoreline, and the tide was sufficiently high at the time of the spill to carry the spill onto the sites in question. In the communities further north, such as Three Brothers, Smith's Creek, and Morowhanna, river water occasionally overflows the empoldered[22] areas created for farming, resulting in salt-water intrusion. In Region 2, crop cultivation is present in many communities along the coast (including but not limited to Charity/Urasara, Evergreen/Paradise, Anna Regina, and Good Hope/Pomona) and ranges in scale from subsistence farming of rice and other staple grains, to export-oriented cash crops of coconuts and watermelons. Similarly, spilled oil that reaches the river systems could end up in these farming areas. These effects are considered highly unlikely, as the movement of oil upstream would be limited by tidal action.

[22] Empoldering refers to the act of making land that is periodically flooded available for cultivation through the erection of banks and levees to control inundation and drainage.

However, due to the relatively limited diversification of the economy in Region 1 and Region 2, the intensity of a marine oil spill that reaches the Guyana coast on socioeconomic conditions and employment and livelihoods in coastal agricultural communities is considered **Medium**. The geographic extent of an unmitigated marine oil spill would include coastal areas within the **Indirect AOI**. On the basis that impacts from an unmitigated marine oil spill would continue over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming no mitigation of the marine oil spill, would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Large**. Consistent with the sensitivity ratings assigned for socioeconomic impacts from planned events on vulnerable populations in the SBPA and coastal Region 1 areas, a sensitivity rating of **High** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. As described above, a marine oil spill is considered **Unlikely**. The risk to socioeconomic conditions and employment and livelihood for coastal agriculture individual(s) from an unmitigated marine oil spill is considered **Moderate** (see Table 9.15-1).

In the unlikely event of a marine oil spill, farmers in coastal communities in potentially affected area would have ample notice to close sluice gates, and spill responders would have time to install absorbent booms or other spill control equipment to prevent oil from reaching farmers' crops or drainage inlets. These actions and the mitigation measures of OSRP implementation would serve to considerably reduce the intensity of such an impact from a marine oil spill to **Low**. On the basis that a mitigated marine oil spill in the **Indirect AOI** coastal areas would continue over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming mitigation of the spill, would be reduced to more than a week but less than a year, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Considering the claims and/or livelihood remediation processes would further reduce the risk to livelihoods by compensating for economic losses, a sensitivity rating of **Medium** is assigned for the residual risk rating. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described above, a marine oil spill is considered **Unlikely**, and the residual risk to socioeconomic conditions and employment and livelihood for coastal agriculture individual(s) from a mitigated marine oil spill is therefore considered **Minor** (see Table 9.15-1).

9.15.2. Coastal Fuel Spill

9.15.2.1. Risk to Commercial and Artisanal Fishing

The intensity of an unmitigated coastal fuel spill impacting commercial and/or subsistence fisheries would be **High** given (1) the importance of the fishing industry to the national Guyanese economy; (2) the likelihood that a response within the Demerara River would interfere with normal vessel traffic in the river; and (3) the fact that the most important fishing port in Guyana (Meadowbank) is located in Region 4 on the Demerara River. The Meadowbank

port is nationally significant not only because of the amount of fish landed there, but also because of its proximity to the population center of the greater Georgetown area.

The geographic extent of an unmitigated coastal fuel spill would include (limited) portions of the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal fuel spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Large**. Consistent with the sensitivity ratings assigned for socioeconomic impacts from planned events on individuals and households within Region 4 (which can be more economically diverse) and those of lower socioeconomic status from other regions who fish in the Demerara River and use the Meadowbank port, a sensitivity rating of **Medium** to **High** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High.** As described above, a coastal fuel spill is considered **Unlikely**. Therefore, the pre-mitigation risk to socioeconomic conditions and employment and livelihood for fisherfolk or other economic users of affected coastal waterways from an unmitigated coastal fuel spill is considered **Moderate**.

Effective implementation of the OSRP would reduce the intensity of this risk to **Medium** by reducing the area affected by such a spill, likely to only a portion of the **Indirect AOI**. On the basis that impacts from a mitigated coastal fuel spill could persist over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming mitigation of the spill, would be reduced to more than a week but less than a year, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**. Additionally, a claims process and, as appropriate, a livelihood remediation program (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established at the onset of a coastal fuel spill of sufficient magnitude to affect livelihoods of fisherfolk as well as other affected stakeholders (e.g., should mobility of transport and access to markets via aquatic networks be impacted). Considering the claims and/or livelihood remediation processes would further reduce the risk to fisherfolk by compensating for economic losses, a sensitivity rating of **Medium** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium.** As described above, a coastal fuel spill is considered **Unlikely**, and the residual risk to socioeconomic conditions and employment and livelihood for coastal agriculture individual(s) from this unplanned event is considered **Minor** (see Table 9.15-1).

9.15.2.2. Risk to Coastal Agriculture

As described in Section 9.21, Land Use, depending on the location of a coastal fuel spill, marine diesel could enter the Georgetown Harbour / Demerara River estuary. There are only a few areas along the shore zone or coastal areas near Georgetown and on the western bank of the

Demerara River bank that are used for agricultural purposes—specifically, subsistence farming and/or grazing of livestock in Region 3. These areas are set back from the coast and protected by either manmade structures (e.g., seawall) or mangroves. A potential coastal spill would only affect land use in these areas if it occurred in proximity to one of the sites, were sufficiently large to reach the shoreline, and the tide was sufficiently high at the time of the spill to carry the spill over the bank and onto the sites in question.

Rice farming, which makes up the majority of agricultural activity in the coastal area of Regions 2 and 3, would not be directly impacted by a coastal fuel spill since rice fields are irrigated from inland water conservancies. However, the islands at the mouth of the Essequibo River, including Leguan and Wakenaam, use freshwater from the river for irrigation of rice crops. It is unlikely that a coastal fuel spill in the vicinity of Georgetown Harbour would reach the Essequibo River area.

Depending on tidal conditions and extent of spread of the spill, a coastal fuel spill also could prevent the opening up of sluices to allow for drainage of lands along the Demerara River. Closure of sluices could prevent the spill moving inland into canals, but if such closure happens in the rainy season, it could affect area drainage and lead to water accumulation on lands and flooding as a result. However, if this were to occur, the limitation on opening sluices would be expected to be short-term in nature, reducing the consequence from a flooding perspective.

Due to the relatively limited diversification of the economy in Region 3, the intensity of a coastal fuel spill that reaches the Guyana coast on socioeconomic conditions and employment and livelihoods in coastal agricultural communities is considered **Medium**. The geographic extent of an unmitigated coastal fuel spill could include coastal areas within a small portion of the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal fuel spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**. Consistent with the sensitivity ratings assigned for socioeconomic impacts from planned events on individuals and households of lower socioeconomic status, a sensitivity rating of **High** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. As described above, a coastal fuel spill is considered **Unlikely**. The risk to socioeconomic conditions and employment and livelihood for coastal agriculture individual(s) in Region 3 from this unplanned event is considered **Moderate** (see Table 9.15-1).

In the event of a coastal fuel spill, the spill would be quickly controlled and contained because of the smaller volumes and the ready access to spill control equipment. The mitigation measures of OSRP implementation would serve to considerably reduce the intensity risk of such an impact from a coastal fuel spill to **Low**. The affected area within the **Indirect AOI** would be limited and of short duration, and a relatively rapid environmental recovery would be expected. On this basis, the frequency is considered to be **Continuous** and duration is considered to be **Medium-**

term. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Considering the claims and/or livelihood remediation processes would further reduce the risk to livelihoods by compensating for economic losses, a sensitivity rating of **Medium** is assigned. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**.

As described above, a coastal fuel spill is considered **Unlikely**, and the residual risk to socioeconomic conditions and employment and livelihood for coastal agriculture individual(s) from a mitigated coastal fuel spill is considered **Minor** (see Table 9.15-1).

An onshore spill, such as a spill from fuel storage at a shorebase facility, would be limited in extent due to its lower volume, if such a spill were to impact an agricultural area at all. Such a spill would be further reduced through effective implementation of the onshore/nearshore response actions described in the OSRP. The risk to coastal agriculture from residual impacts of an onshore spill is equal to or less than that from an on-water/nearshore spill and does not affect the residual risk rating of the coastal fuel spill scenarios.

9.15.3. Project Vessel Collision with a Third-Party Vessel

9.15.3.1. Risk to Third-Party Vessel Operators

There is a potential for collisions between Project vessels and other non-Project vessels in the Georgetown Harbour / Demerara River area. Such an incident may result from navigation error or a temporary loss of power that affects the ability of a Project vessel to steer. From a socioeconomic conditions and employment and livelihoods perspective, the potential impact of such an event could include loss of the equipment necessary for the affected individual to retain his/her livelihood, or an injury which could result in the same effect. On this basis, the intensity of such an event could potentially be **High**.

The geographic extent of a project vessel collision would be within the **Direct AOI**. On the basis that impacts from a project vessel collision would occur only occasionally, the frequency is considered to be **Episodic**. The unmitigated effects of loss of livelihood as a result of a significant vessel collision could have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**. Consistent with the sensitivity ratings assigned for socioeconomic impacts from planned events, a sensitivity rating of **Medium** to **High** is assigned depending upon the individual/third-party vessel affected. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/ severity designation of **Medium** to **High**.

Section 9.1.1.4, Nearshore Collision between a Project Supply Vessel and a Third-Party Vessel or Structure, or Grounding, includes a summary of the embedded controls that will be in place to reduce the potential for a nearshore collision to occur. Based on consideration of these controls, the likelihood of Project vessel accidents causing any significant damage to third party vessels, or causing significant injury, is considered **Unlikely**. Similarly, Section 9.1.1.6, Offshore

Collision between Project Vessels or between a Project Vessel and a Third-Party Vessel, includes a summary of the embedded controls that will be in place and the additional mitigation measures that will be employed to reduce the potential for an offshore collision to occur. Based on these controls and measures, the potential for an offshore collision between a Project vessel and another third party vessel is also considered **Unlikely**.

In combination with a likelihood rating of **Unlikely** for a vessel collision, the pre-mitigation risk to socioeconomic conditions and employment and livelihood from this unplanned event is considered **Minor** to **Moderate** (see Table 9.15-1). Mitigation measures consistent with good international oilfield practices, together with existing embedded controls, will be implemented in the unlikely event of a vessel collision. In case of a collision involving a Project vessel and a non-Project vessel that may result in a claim arising from such type of incident, restitution would be provided in appropriate cases, consistent with governing contracts and applicable laws. On this basis, the intensity would be reduced (reducing the magnitude to **Medium**) and the sensitivity would be reduced to no more than **Medium**, resulting in a residual risk rating of no more than **Minor**.

Table 9.15-1: Risk Ratings for Unplanned Event Impacts on Economic Conditions/Employment and Livelihoods

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Fisherfolk Other economic users of marine waters	Unlikely	High	Moderate	Implement OSRP Implement claims and/or livelihood remediation processes for affected individuals	Minor
	Coastal agricultural communities in Region 1	Unlikely	High	Moderate		Minor
Coastal Fuel Spill	Fisherfolk Other economic users of marine waters	Unlikely	High	Moderate		Minor
	Coastal Agricultural Communities	Unlikely	High	Moderate		Minor
Vessel Collision	Non-Project vessel operators	Unlikely	High	Minor to Moderate	Restitution consistent with applicable law	Minor

9.16. COMMUNITY HEALTH AND WELLBEING

As indicated in Table 9.1-6, the unplanned events with the potential to result in measurable impacts on community health and wellbeing include a marine oil spill, a coastal fuel spill, a vehicular accident involving a Project vehicle, and a collision between a Project vessel and a non-Project vessel.

9.16.1. Marine Oil Spill

Although Guyana as a nation is considered self-sufficient for food, disparities in food supply and family incomes create challenges in maintaining food security and proper nutrition in some communities, particularly rural populations. The result is that malnutrition and anemia are among the leading causes of death in Guyanese children.

Rural communities on the Guyanese coast are dependent on fishing and agriculture for subsistence and livelihoods. Fish catches and traditional crops such as vegetables and fruits are consumed or often sold locally at markets or roadside stands in all regions. Crabbing, shrimping, and hunting of coastal game, such as iguanas, deer, agouti, labba, and shorebirds, are also practiced for subsistence in many coastal communities, and are especially critical for indigenous communities in Regions 1 and 2. Adverse impacts on these resources as a result of an oil spill could have direct health impacts through entry of harmful substances into the food chain, or through malnutrition if local food supplies become unavailable. Impacts on these sectors could also have impacts via the social determinants of health. If livelihoods are impacted, increased household poverty can impact economic security, quality of life, access to education, and other health-promoting and health-protective resources. Increased economic hardship can also lead to or exacerbate familial problems and mental health impacts, including increased anxiety and suicide, especially for already vulnerable populations.

As described in Section 9.1.5, Oil Spill Modeling Results, stochastic oil spill modeling for the Most Credible WCD and Maximum WCD scenarios indicates a 5 to 40 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 1 and a 5 to 10 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 2. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain offshore of Guyana for the Most Credible WCD scenario and for the Maximum WCD (Jun-Nov) scenario. Deterministic modeling predicts impact across the majority of the Region 1 shoreline for the (Dec–May) Maximum WCD scenario. Modeling mitigation under this scenario predicts a reduction in the predicted length of shoreline impact in Region 1, but the predicted length still represents the majority of the Region 1 shoreline. The deterministic modeling analysis does not predict shoreline impacts in Guyana outside of Region 1 for either the Most Credible WCD or Maximum WCD scenarios, regardless of season or the effects of mitigation. The intensity of an unmitigated marine oil spill impacting food availability in coastal communities, and therefore the health of affected coastal communities, is considered **High**. This is due to the following factors: (1) dependence on the coastal environment for subsistence and income and the use of rivers for transportation and daily household activities such as washing as well as bathing; (2) the high rate of poverty; and (3) the current health challenges faced by the coastal population in Guyana; and (4) the

potential for human exposure to oil constituents through pathways such as inhalation and consumption of contaminated sea food. The geographic extent of an unmitigated marine oil spill would include portions of the **Indirect AOI**. On the basis that impacts from an unmitigated marine oil spill could persist over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming no mitigation of the marine oil spill, would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**. Consistent with the sensitivity ratings assigned for potential impacts on community health and wellbeing for receptors outside of Georgetown from planned activities, a sensitivity rating of **Medium** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. A marine oil spill is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to community health and wellbeing from a marine oil spill is considered **Moderate**.

Effective implementation of the OSRP would reduce this risk by reducing the geographic area affected by such a spill. Additionally, a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established to further reduce this risk by compensating for economic losses (which would further mitigate potential follow-on community health and wellbeing effects due to loss of sustenance). Accordingly, the intensity of such an impact would be reduced to **Medium**. The geographic extent of an unmitigated marine oil spill would still include portions of the **Indirect AOI**. On the basis that the impact from a mitigated marine oil spill could persist over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming mitigation of the spill, would be reduced to more than a week, but less than a year, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Consistent with the sensitivity ratings assigned for potential impacts on community health and wellbeing for receptors outside of Georgetown from planned activities, a sensitivity rating of **Medium** is assigned. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a marine oil spill is considered **Unlikely**. On this basis, the residual risk rating is reduced to **Minor**.

9.16.2. Coastal Fuel Spill

The potential health effects associated with a coastal fuel spill could be similar for an on-water spill. However, the intensity of such a spill impacting food availability and therefore the health of affected coastal communities is considered **Medium** based on the fact that the affected geographic area within the **Indirect AOI** would be more limited, which would create more potential for subsistence fisherfolk to access alternative areas for fishing. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce

significantly with time as the spilled diesel fuel continued to weather), and because the impacts of an unmitigated coastal fuel spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**. Consistent with the sensitivity ratings assigned for potential impacts on community health and wellbeing for receptors outside of Georgetown from planned activities, a sensitivity rating of **Medium** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 9.1.5, Oil Spill Modeling Results, a coastal fuel spill is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to community health and wellbeing from a coastal fuel spill is considered **Minor**.

Effective implementation of the OSRP would reduce this risk by reducing the geographic area affected by such a spill. Additionally, a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established to further reduce this risk by compensating for economic losses (which would further mitigate potential follow-on community health and wellbeing effects due to loss of sustenance). Accordingly, the intensity of such an impact would be reduced to **Low**. The geographic extent of an unmitigated coastal fuel spill would still include portions of the **Indirect AOI**. On the basis that impacts from a mitigated coastal fuel spill could persist over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming mitigation of the spill, would be reduced to more than a week but less than a year, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**. Consistent with the sensitivity ratings assigned for potential impacts on community health and wellbeing outside of Georgetown from planned activities, a sensitivity rating of **Medium** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a coastal fuel spill is considered **Unlikely**; therefore, the residual risk rating remains at **Minor**.

The potential health effects associated with an onshore spill, such as a spill from fuel storage at a shorebase facility, would be reduced through effective implementation of the onshore/nearshore response actions described in the OSRP. Compared to an on-water or nearshore spill, the onshore spill scenario involves a significantly smaller spill volume (less than 10 bbl) and improved access and timing for spill response containment and removal. It is possible that impacted soils or groundwater could extend the duration of potential human exposure while cleanup activity is occurring. Therefore, the risk to human health from residual impacts of an onshore spill is equal to or less than that from an on-water/nearshore spill and does not affect the residual risk rating of the coastal fuel spill scenarios.

9.16.3. Vehicular Accident

Regarding the potential impact of onshore traffic accidents on community health and wellbeing, additional vehicular trips generated by the Project would be expected to increase the risk of vehicular accidents. The relatively low traffic speeds in Georgetown due to existing congestion may reduce the likelihood of serious injuries resulting from a vehicular accident, although the risk to bicyclists and pedestrians would not be reduced as much due to low vehicle speeds. However, vehicular accidents involving Project and non-Project vehicles could lead to consequences ranging from minor vehicle damage to injury or loss of life.

Consistent with good international oilfield practice, as an embedded control, EEPGL has developed and implemented an EEPGL-wide Road Safety Management Procedure, which covers drivers and equipment dedicated to the Project to mitigate these risks. The Procedure includes, but is not limited to, the following components:

- Definition of required driver training, including (but not limited to) defensive driving, loading/unloading procedures, and safe transport of passengers, if applicable;
- Designation and enforcement of speed limits, through speed governors, global positioning system, or other monitoring systems;
- Avoidance of deliveries during typical peak traffic hours as well as scheduled closures of the Demerara Harbour Bridge to road traffic (i.e., when traffic conditions worsen along the East Bank Demerara Road), to the extent reasonably practicable;
- Monitoring and management of driver fatigue;
- Definition of vehicle inspection and maintenance protocols that include all applicable safety equipment;
- Implementation of a community safety program for impacted schools and neighborhoods to improve traffic safety; and
- Community outreach to communicate information relating to major delivery events or periods.

The intensity of the impact of onshore traffic accidents in and around Georgetown (within the **Direct AOI**) on community health and wellbeing would depend on the nature of the accident and extent of injury, and thus could range from **Negligible** to **High**. The duration of the impact (from **Short-term** to **Long-term**) would be a function of the nature of the accident. The frequency of the impact would be **Episodic**, as an onshore traffic accident would occur no more than occasionally and at irregular intervals. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible** to **Medium**. Consistent with the sensitivity ratings assigned for potential impacts on community health and wellbeing in Georgetown from planned activities, the sensitivity rating is considered **Medium**.

Applying the methodology in Chapter 4 and considering the above-referenced suite of embedded controls (many of which would serve to reduce the severity of a vehicular accident,

were it to occur) these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low** to **Medium**.

Based on the results of a traffic survey completed for key road intersections across Georgetown anticipated to potentially be among those more heavily used by EEPGL-related vehicle movements (see Appendix T, Traffic Impact Assessment), additional EEPGL-related vehicle trips (considering the Project and other anticipated EEPGL activities) will not meaningfully change traffic congestion at any of the 2019 study intersections. This suggests the likelihood of a vehicular accident involving a Project vehicle is **Unlikely**. However, considering the planned life cycle for the Project (at least 20 years), the likelihood of an event is conservatively considered to be **Possible**.

In combination with a consequence ranging from **Low** to **Medium**, this leads to a risk rating for vehicular accidents of **Minor** to **Moderate**. Beyond the embedded controls described above, no additional mitigation measures are reasonably practicable. Accordingly, the residual risk rating for vehicular accidents remains **Minor** to **Moderate** (see Table 9.16-1).

9.16.4. Marine Vessel Collision

Accidents involving Project and non-Project vessels could lead to consequences ranging from minor vessel damage to injury or loss of life. The consequence of such an event would be a function of the nature of the accident, and could range from **Low** to **High** depending on the extent of damage and severity of any resultant injuries.

The Project-related increase in vessel traffic is expected to be an insignificant incremental addition to the existing vessel traffic in Georgetown Harbour (the most likely location where a vessel collision could occur, as compared to the open ocean). Based on the results of a marine vessel traffic survey conducted along the Demerara River in the vicinity of the shorebases that will be used by the Project (see Section 8.4.2.2, Existing Conditions in the Project Area of Influence), the average daily marine vessel traffic in Georgetown Harbour is on the order of 700 to 1,000 vessel movements per week. In comparison, based on current drilling activities and past experience with similar developments, it is estimated that during the Yellowtail Project development well drilling and FPSO/SURF installation, an average of approximately 12 to 15 round-trips (24 to 30 one-way trips) per week may be made between the Stabroek Block and shorebases by marine installation and support vessels. During Yellowtail FPSO/SURF production operations, it is estimated that this number will be reduced to approximately 5 to 10 round-trips (10 to 20 one-way trips) per week. These vessel round-trips will be loaded and offloaded at shorebase facilities in Guyana and/or Trinidad and Tobago. These additional Project-related marine vessel trips represent an approximately 2 to 4 percent increase (during drilling and installation) and an approximately 1 to 3 percent increase (during production operations).

The intensity of the impact of a marine vessel collision within the **Direct AOI** on community health and wellbeing would depend on the nature of the accident and extent of injury, and thus could range from **Negligible** to **High**. The duration of the impact (from **Short-term** to **Long-term**) would be a function of the nature of the accident. The frequency of the impact would be

Episodic, as a marine vessel collision would occur no more than occasionally and at irregular intervals. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible** to **Medium**. Consistent with the sensitivity ratings assigned for potential impacts on community health and wellbeing in/around Georgetown from planned activities, the sensitivity rating is considered **Medium**.

Applying the methodology in Chapter 4 and considering the above-referenced suite of embedded controls, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low** to **Medium**. As an embedded control measure, Project vessels operating near the coast will adhere to speed restrictions and navigation aids, which should further reduce the likelihood of a collision. Considering these factors, the likelihood of a collision between a Project vessel and a non-Project vessel is considered **Unlikely**.

In combination with a consequence ranging from **Low** to **Medium**, this leads to a risk rating for vessel collisions of **Minor**. Beyond the embedded controls described above, no additional mitigation measures are reasonably practicable. Accordingly, the residual risk rating is maintained as **Minor**.

Table 9.16-1: Risk Ratings for Unplanned Event Impacts on Community Health and Wellbeing

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Community Health and Wellbeing	Unlikely	High	Moderate	Implement OSRP; institute claims and livelihood remediation process, as necessary	Minor
Coastal Fuel Spill	Community Health and Wellbeing	Unlikely	Medium	Minor	Implement OSRP; institute claims and livelihood remediation process, as necessary	Minor
Vehicular Accident	Community Health and Wellbeing	Possible	Low to Medium	Minor to Moderate	None	Minor to Moderate
Marine Vessel Collision	Community Health and Wellbeing	Unlikely	Low to Medium	Minor	None	Minor

9.17. MARINE USE AND TRANSPORTATION

As indicated in Table 9.1-6, the unplanned events with the potential for measurable impacts on marine use and transportation would be a marine oil spill, a coastal fuel spill, and a collision between a Project vessel and a non-Project vessel.

9.17.1. Marine Oil Spill or Coastal Fuel Spill

Depending on the extent of the spill, an oil spill could render offshore or nearshore areas inaccessible for a period of time. This limitation on accessibility could affect the locations in which commercial or subsistence fishing could be conducted. For oil spills that reach nearshore waters, this could also affect river and coastal transportation networks that link communities and provide access to markets, especially in Region 1 and between Regions 2 and 3, where aquatic transportation is the only method of transportation available. Both of these impacts could result in follow-on impacts on livelihoods. These potential follow-on impacts are discussed in Section 9.15, Socioeconomic Conditions / Employment and Livelihoods.

With respect to potential impacts on marine use and transportation, intensity of the impact from an unmitigated marine oil spill is conservatively considered **High**. In the case of an unmitigated coastal fuel spill, the extent of the spill would likely be comparatively smaller than a marine oil spill, creating less potential for marine use and transportation impacts to be experienced by other vessel operators or users of marine infrastructure. On this basis, in the case of an unmitigated coastal fuel spill, the intensity of impacts on marine use and transportation is considered **Medium**.

The geographic extent of an unmitigated marine oil spill would include portions of the **Indirect AOI**. The geographic extent of a coastal fuel spill would likely be more limited, but could still include portions of the **Indirect AOI**. In the absence of mitigation, the impacts of both events would persist as long as the spill was present in the affected area, so the frequency is considered to be **Continuous**. Depending on the size of the spill, the effects of a marine oil spill, assuming no mitigation of the spill, would have the potential to extend beyond a year, so duration is conservatively considered to be **Long-term**. Impacts from a coastal fuel spill, assuming no mitigation, would be expected to reduce significantly with time as the spilled fuel weathers, reducing the likely duration to no more than **Medium-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large** for a marine oil spill and **Medium** for a coastal fuel spill. Consistent with the sensitivity ratings assigned for potential impacts on marine use and transportation from planned activities, a sensitivity rating of **Low** is assigned for commercial vessels, which have a greater means of adapting to changes, and **Medium** for subsistence fishing vessels, which have a comparatively lower means of adapting to changes.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a pre-mitigation consequence/severity designation of **Medium** to **High** for a marine oil spill and **Low** to **Medium** for a coastal fuel spill. As described in Section 9.1.5, Oil Spill Modeling Results, a marine or coastal fuel spill is considered **Unlikely**. Accordingly, the pre-mitigation risk to marine use and transportation as a result of a marine oil spill is considered **Minor** to **Moderate** and the pre-mitigation risk to marine use and transportation as a result of a coastal fuel spill is considered **Minor**.

Effective implementation of the OSRP would reduce the direct risk of the oil spill by reducing the geographic area affecting marine users. However, a mitigated marine or coastal fuel spill could also have some impact on marine use and transportation as a result of the additional marine

vessels and resources that would be mobilized to support spill response (as described in the OSRP), potentially resulting in increased marine congestion in and around Georgetown Harbour. The consequence/severity of increased congestion with respect to impacts on marine use and transportation in and around Georgetown Harbour would depend on the number of additional vessel movements resulting from response efforts, which would itself depend on the nature and extent of the oil spill. In the case of a response to the loss-of-well-control marine oil spill scenario discussed in Section 9.1.5, Oil Spill Modeling Results, the level of response activity would be moderate to high over the response period. On this basis, in the case of a marine oil spill, increased congestion (as a result of response) could cause vessel operators or other users of infrastructure would have the potential to noticeably reduce waterway or transportation infrastructure capacity in Georgetown Harbour, but not to the extent that they would require a change in travel behavior by other waterway users. In the case of a coastal fuel spill, the extent of the spill (and thus the level of additional response vessel activity) would likely be comparatively smaller than a marine oil spill, creating comparatively less potential for congestion-related impacts to be experienced by other vessel operators.

While there would still be impacts to marine use and transportation due to increased vessel congestion during the response, the overall intensity of a mitigated spill (balancing the reduced geographic area that would be affected under a mitigation scenario with the additional vessel traffic associated with the mitigation) would likely be reduced to no more than **Medium** for both marine oil spill and coastal fuel spill scenarios. The duration would be reduced to no more than **Medium-term** for both scenarios, thus reducing the magnitude of a marine oil spill or coastal fuel spill to **Medium** and the consequence/severity (considering the range of receptor sensitivities) to **Low** to **Medium**. Accordingly, the residual risk rating of potential impacts of marine oil and coastal fuel spills is reduced to **Minor**.

9.17.2. Project Vessel Collision with a Third-Party Vessel

As in the case of an oil spill, a collision between a Project vessel and a third-party vessel could result in follow-on impacts from a livelihood perspective (e.g., if a commercial or subsistence fishing vessel were damaged to the extent that its usability was to be impacted). These potential follow-on impacts are discussed in Section 9.15, Socioeconomic Conditions / Employment and Livelihoods.

In addition to this type of follow-on impact, vessel collisions in Georgetown Harbour or coastal areas could interfere with marine use and transportation if the collision results in one or both of the vessels becoming temporarily immobilized such that they present an obstruction to other marine traffic. This scenario would be relevant only in the instance of a collision in Georgetown Harbour (as such a scenario in open coastal waters would not reasonably be expected to present an obstruction to navigation). Accordingly, the assessment of risks from a vessel collision is thus focused on the scenario of a collision in Georgetown Harbour.

Even if a collision is of sufficient magnitude to result in a vessel becoming temporarily immobilized such that it presents an obstruction to other marine traffic in Georgetown Harbour, it is likely the affected vessel could be relocated relatively quickly. Furthermore, Georgetown

Harbour is sufficiently wide to allow vessels to pass around a potential obstruction until such time as the obstruction is cleared. On this basis, the intensity of a vessel collision with respect to potential impacts on marine use and transportation is considered **Low** to **Medium**, depending upon severity of the incident. The geographic extent would be limited to the **Direct AOI.** On the basis that impacts on marine use and transportation from the obstruction would persist as long as the obstruction was in place, the frequency is considered **Continuous**. The impact on marine use and transportation would likely not extend past a week, so the duration would likely be **Short-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity ratings assigned for potential impacts on marine use and transportation from planned activities, a sensitivity rating of **Low** to **Medium** is assigned depending on the type of vessel (i.e., **Medium** for a subsistence fishing vessel with lesser means to avoid an obstruction resulting from another vessel becoming immobilized as a result of a collision, and **Low** for a commercial vessel with a greater means of avoiding such an obstruction). This leads to a consequence/severity rating of **Low**.

As discussed in Chapter 13, Recommendations, Project vessels will be operated in accordance with standard international and local navigation procedures, which will reduce the likelihood (as well as the potential consequence) of a vessel collision. On this basis, the likelihood of a collision between a Project vessel and a third-party vessel in or around Georgetown Harbour is considered **Unlikely**.

Accordingly, the pre-mitigation risk to marine use and transportation as a result of a vessel collision is considered **Minor**. While prompt response and removal of any grounded or damaged vessel would serve to further reduce the consequence of such an impact, the residual risk rating is maintained at **Minor** (see Table 9.17-1).

Table 9.17-1: Risk Ratings for Unplanned Events/Vessel Collisions on Marine Use and Transportation

Unplanned Event	Resource	Likelihood of Event	Consequence/ Severity	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Use and Transportation	Unlikely	Medium to High	Minor to Moderate	Implement OSRP	Minor
Coastal Fuel Spill	Marine Use and Transportation	Unlikely	Low to Medium	Minor	Implement OSRP	Minor
Vessel Collision	Marine Use and Transportation	Unlikely	Low	Minor	Prompt removal of damaged vessel	Minor

9.18. SOCIAL INFRASTRUCTURE AND SERVICES

As indicated in Table 9.1-6, the unplanned events with the potential to result in measurable impacts on social infrastructure and services include a marine oil spill, a coastal fuel spill, and a vehicular accident.

9.18.1. Marine Oil Spill (Response Efforts)

A marine oil spill could impact social infrastructure and services primarily as a result of spill response efforts. Depending on the extent of the required response, an increased demand for lodging for response teams may be the most likely impact on social infrastructure and services. These increased demands would be temporary, existing only for the duration of required cleanup; this would likely be in the range of a few weeks to months, depending on the extent of the spill and complexity of remediation efforts. If the spill remains offshore, infrastructure and service demands would likely be concentrated in Georgetown, where most response vessels would likely be based, and where infrastructure and services capacities are greater. However, if oil were to reach the Guyana shoreline, land-based response efforts would be required and lodging demands may extend to coastal communities in Region 1. The duration of response efforts would also likely be greater.

The impacts on social infrastructure and services could be different depending on the locations in which response support teams are stationed. Georgetown would be the primary command center for overall response coordination, while additional location(s) for stationing response teams may also be established as required for forward operating base(s). Therefore, separate discussions are provided below for potential risks to social infrastructure and services in Georgetown (the likely primary command center) and Region 1 (a possible additional location for a forward-operating base, based on spill modeling results, which indicate the potential for a shoreline impact in Region 1 under certain seasonal conditions, and based on the fact that potential impacts from a forward-operating base would likely be greatest for a base in Region 1 given logistical challenges). See Section 9.24, Transboundary Impacts, for a discussion of potential transboundary impacts.

9.18.1.1. Georgetown

Referring to the definitions used to assess potential impacts on temporary lodging from planned Project activities (Section 8.5, Social Infrastructure and Services), the intensity of potential impacts on lodging in Georgetown (where the response workforce would likely be concentrated) as a result of response to a mitigated marine oil spill is conservatively predicted to be **Low.** Considering the potential size of a response workforce as compared to the extensive inventory of available lodging in Georgetown (i.e., more than 3,300 rooms), an associated increase in demand for lodging may be perceptible but would likely only cause minimal changes in availability.

The geographic extent of this impact would be focused on Georgetown (i.e., within the **Direct AOI**). On the basis that the additional lodging demands would persist throughout the spill response effort, the frequency is considered to be **Continuous**. Response efforts would likely be completed within a year or less, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Small**.

As noted in the discussion of potential impacts on lodging from planned activities, the sensitivity of Georgetown receptors to lodging impacts is conservatively rated as **Medium**. Applying the

methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**.

In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall pre-mitigation risk to Georgetown lodging infrastructure from a marine oil spill would be **Minor**.

9.18.1.2. Region 1

In the event of a marine oil spill impacting a Guyana shoreline in Region 1, it is possible that logistical needs of a response effort may warrant establishing workforce operating bases down-current of the spill origin (i.e., along the coast of Region 1). Such a response effort could conceivably involve more than 100 Guyanese and foreign responders who would require temporary lodging.

Depending upon the nature of the spill, it is probable that EEPGL would establish housing or berthing for the response teams by building temporary camp structures (e.g., tents) or using a berthing vessel. This would reduce the need to rely on the minimal lodging infrastructure and service capacity that exists in Region 1. Therefore, the intensity of a potential impact on Region 1 lodging as a result of the response effort to a marine oil spill involving workforce presence in Region 1 would likely be no more than **Medium**. This impact would affect limited portions of the **Indirect AOI**. On the basis that the additional lodging demands would persist throughout the spill response effort, the frequency is considered to be **Continuous**. Response efforts would likely be completed within a year or less, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**.

Consistent with the sensitivity ratings assigned for potential impacts on social infrastructure and services, specifically lodging, a sensitivity rating of **Medium** is assigned assuming that the impact would affect lodging capacity and prices primarily in Region 1, where capacity is limited.

In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall pre-mitigation risk to Region 1 lodging infrastructure from a marine oil spill would be **Minor**.

9.18.2. Coastal Fuel Spill (Response Efforts)

A coastal fuel spill would likely only happen in Regions 3 or 4—near the shorebases or near the mouth of the Demerara River. The available capacity of social infrastructure and services in Regions 3 and 4 is comparatively larger than in Region 1. Accordingly, the assessment of potential increased demand for lodging to support coastal fuel spill response focuses on Georgetown infrastructure, as this is where the response workforce would likely be based.

Referring to the definitions used for assessment of potential impacts on temporary lodging from planned Project activities, the intensity of potential impacts on lodging in Georgetown as a result of response efforts to a mitigated coastal fuel spill is conservatively predicted to be **Low**. This takes into consideration the limited size of a response workforce as compared to the inventory of available lodging in Georgetown. The associated increases in demand for lodging may be perceptible, but would likely only cause slight changes in availability. The geographic extent of

such impacts would be focused on Georgetown (i.e., within the **Direct AOI**). On the basis that the additional lodging demands would persist throughout the spill response effort, the frequency is considered to be **Continuous**. Response efforts would likely be completed for the most part or entirely within a year or less, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**.

As noted in the discussion of potential impacts on lodging from planned activities, the sensitivity of Georgetown receptors to lodging impacts is conservatively rated as **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/ severity rating of **Low**.

In combination with a likelihood rating of **Unlikely** for a coastal fuel spill, the overall pre-mitigation risk to Georgetown lodging infrastructure from a coastal fuel spill would be **Minor**.

9.18.3. Vehicular Accident

A vehicular accident could affect social infrastructure and services as a result of temporary increases in road congestion (i.e., until an accident is cleared) or burdening of healthcare infrastructure in the case of an accident requiring medical services. In the case of potential road congestion, vehicular accidents in Guyana are generally cleared from the roadway in a timely manner. In the case of potential impacts on health infrastructure and services, cases requiring medical attention would likely be addressed in Georgetown hospitals, rather than at local-level medical clinics in outlying communities. As documented in Section 8.3, Community Health and Wellbeing, unreliable emergency care, air ambulance services, and overall hospital capacity in Georgetown have been identified as shortfalls of Guyana's medical system, which is being stretched by the present pandemic. However, the burden from a Project-related vehicle accident—even a more serious one—would not be expected to overwhelm the existing capacity in Georgetown.

Accordingly, the intensity of potential impacts on social infrastructure and services in Georgetown would likely be **Negligible**. The geographic extent of such an impact would be focused on Georgetown (i.e., within the **Direct AOI**). Any additional burden on social infrastructure and services would persist throughout the time period during which the accident response and associated medical attention was provided (**Continuous**), but such response efforts would likely be **Short-term** in duration. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible**.

Drawing from the discussions of potential impacts on community health services and additional traffic congestion, the sensitivity of Georgetown receptors to these types of impacts is rated as **Medium**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Low**.

The Project-related increase in traffic is expected to be an insignificant incremental addition to the existing traffic levels in Georgetown. As discussed in Section 9.16, Community Health and Wellbeing, additional EEPGL-related vehicle trips (considering the Project and other anticipated EEPGL activities) are not expected to meaningfully change traffic congestion in the greater

Georgetown area. However, based on the planned life cycle for the Project (at least 20 years), the likelihood of such an event is considered to be **Possible**.

Accordingly, the pre-mitigation risk to social infrastructure and services as a result of a vehicular accident is considered **Minor**. While prompt response and removal of any damaged vehicle would serve to further reduce the consequence of such an impact, the residual risk rating is maintained at **Minor**.

While EEPGL has developed and implemented a Road Safety Management Procedure, as summarized in Section 9.16, Community Health and Wellbeing, to further reduce the likelihood (and consequence) of a vehicular accident, the residual risk rating is maintained at **Minor** (see Table 9.18-1).

Table 9.18-1: Risk Ratings for Unplanned Event Impacts on Social Infrastructure and Services

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill (response efforts)	Social Infrastructure and Services (Lodging)	Unlikely	Low	Minor	None beyond implementation of Road Safety Management Procedure	Minor
Coastal Fuel Spill (response efforts)	Social Infrastructure and Services (Lodging)	Unlikely	Low	Minor	None beyond implementation of Road Safety Management Procedure	Minor
Vehicular Accident	Social Infrastructure and Services	Possible	Low	Minor	None beyond implementation of Road Safety Management Procedure	Minor

9.19. WASTE MANAGEMENT INFRASTRUCTURE CAPACITY

As indicated in Table 9.1-6, the unplanned events with the potential to result in measurable impacts on waste management infrastructure capacity would be a marine oil spill or a coastal fuel spill. A marine oil spill or coastal fuel spill could impact waste management infrastructure capacity primarily as a result of spill response efforts. In contrast, due to the physical nature and qualities associated with a NADF release, such weighted mud/fluids would sink if released as the result of a riser failure during drilling operations. There would be potential for a light sheen to occur, but this would dissipate rapidly. Potential impacts on marine biota, marine geology and sediments, and marine water quality from an NADF release are discussed in other sections of the EIA, but this event would not be expected to result in a material increase in waste generation and, therefore, would not result in potential impacts on waste management infrastructure capacity. In the unlikely event of a marine oil spill or coastal fuel spill, the following types of wastes could be generated:

- Recovered oil
- Oily water mixed with recovered oil
- Sorbent materials
- Oiled containment booms
- Oiled personal protective equipment
- Oiled soil or sediment
- Oiled vegetation
- Oiled debris
- Deceased wildlife

All waste generated as a result of spill response activities would be managed in accordance with EEPGL's countrywide Comprehensive Waste Management Plan (CWMP), OSRP, and Guyana laws and local regulations. Should a significant oil spill occur, an incident-specific waste management plan (to complement the CWMP) may be developed as part of the response. Further, the CWMP may be adapted as required if a spill is likely to produce more waste than can be handled by EEPGL's established waste contractors.

As described in Section 8.6, Waste Management Infrastructure Capacity, the capacity of Guyana-based facilities capable of treating hazardous wastes has been expanding significantly over recent years, and the suite of facilities that will be in place by the time the Project is under development will have the technologies and capacity to treat the bulk of the wastes that would be generated in a spill response.

Non-hazardous solid wastes from EEPGL's operations that are not recyclable and residuals from solid wastes treated by existing and planned Guyana hazardous waste treatment facilities are currently disposed at the Haags Bosch Landfill (HBL). The HBL would also be used for the disposal of the treated residues and other non-hazardous wastes that would be expected to be generated during a spill response.

As discussed in Section 8.6, Waste Management Infrastructure Capacity, a May 2019 capacity assessment indicated that Guyana-based hazardous waste management capacity would likely be unable to keep up with treating the increased volume of EEPGL's hazardous solids and waste oil liquids anticipated to be generated by future EEPGL activities. Since that assessment, there has been significant expansion of third-party commercial hazardous waste handling, storage, and treatment facilities in Georgetown. This has included the addition of a pug mill (for waste stabilization), an additional thermal treatment unit, and a wash bay with pre-/post-treated water storage (for waste treatment) at the Tiger Rentals Guyana Inc. (TRG) facility. Construction is continuing at the TRG facility to add a further 2,000-barrel treated-water storage tank, additional thermal treatment capacity, additional pug mill facilities, and storage for post-treatment solids. Additionally, another third-party, Sustainable Environmental Solutions Guyana, Inc., has developed a new integrated waste management facility (expected to be fully operational in the second half of 2021) at Guyana Shore Base Inc.—designed to manage wastes that are generated from offshore oil and gas operations. The facility will employ various hazardous and non-hazardous waste management technologies, including hot oil thermal

desorption, incineration, decanter/centrifuge separation, wastewater treatment, waste shredding, container crusher/baling, and container washing.

Several additional qualified third-party waste management operators are currently seeking authorization for facility developments or expansions, as discussed above. These are expected to further expand the capacity of onshore waste management infrastructure to manage the Project's hazardous, non-hazardous, and exempt hazardous waste storage, processing, treatment, and/or recycling needs. All of the above facilities could be used to manage wastes resulting in the unlikely event of a spill.

The original HBL disposal cell (Cell 1) is at capacity, and a second cell (Cell 2) started operations in late March 2021 (Damon 2021). The HBL facility currently receives approximately 500 tonnes of waste per day. At current disposal rates, the Government of Guyana estimates that Cell 2 has approximately 4 to 6 years of disposal capacity. This estimated life span of Cell 2 depends upon how much the waste volumes received at the landfill increase with the expanded economic development expected in the Georgetown area over the next 5 years. There remains space for additional cell(s) at the HBL location to be developed in the future. The currently available landfill capacity appears sufficient to support the Project and other users for the short-term, even considering forecasted growth in waste volumes from expanding industrial activity. Presuming additional cell(s) would be constructed on a timely basis, the future HBL capacity also appears reasonable for the longer-term (up to 10 years).

The intensity of impact of a spill on Georgetown-based hazardous waste management infrastructure capacity would be a function of the scale of the spill and the volume of waste materials generated by the response effort. Balancing the above-noted recent and ongoing expansions of hazardous waste treatment infrastructure capacity, the possibility that a major spill could be a significant contributor to hazardous waste treatment demand, and the expectation that other oil and gas-related hazardous waste treatment demand would reduce during response to such a spill, the intensity of potential Project impacts on Georgetown-based hazardous waste treatment facilities is considered to be as much as **Medium**. Potential impacts would be limited to the **Direct AOI** (i.e., Georgetown). On the basis that the impacts would persist throughout the spill response effort, the frequency is considered to be **Continuous**. Response efforts would likely be completed for the most part or entirely within a year or less, so duration is considered to be **Medium-term**. Therefore, the magnitude of this potential impact is rated as **Medium**. Consistent with the sensitivity ratings assigned for potential impacts on non-Project users of Georgetown-based hazardous waste treatment facilities from planned activities, a sensitivity rating of **Low** is assigned, on the basis that these users have the ability to access alternate regional providers for this service.

Applying the methodology in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.5, Oil Spill Modeling Results, a likelihood rating of **Unlikely** for a marine oil spill and a coastal fuel spill is applied. Accordingly, the overall pre-mitigation risk to the Georgetown-based hazardous waste treatment facilities component of

waste management infrastructure capacity from a marine oil spill or coastal fuel spill is considered **Minor** (see Table 9.19-1).

As with hazardous waste treatment facilities, the intensity of impact of a spill on Georgetown-based non-hazardous waste management (landfill) capacity would be a function of the scale of the spill and the volume of waste materials generated by the response effort. However, even with a large spill, it is not likely that response-related wastes would comprise a significant proportion of the total current demand on Georgetown-based landfill facilities (on the order of approximately 15,000 tonnes per month). However, under the assumption that a large spill could produce a significant increase in the Project's waste volume during the response effort, the intensity of potential Project impacts on Georgetown-based landfill facilities (in the absence of capacity expansions and/or the introduction of additional facilities of a sufficient quality) is conservatively rated as **Medium**. Potential impacts would be limited to the **Direct AOI** (i.e., Georgetown). On the basis that the impacts would persist throughout the spill response effort, the frequency is considered to be **Continuous**. Response efforts would likely be completed for the most part or entirely within a year or less, so duration is considered to be **Medium-term**. Therefore, the magnitude of this potential impact is rated as **Medium**. Consistent with the sensitivity ratings assigned for potential impacts on non-Project users of Georgetown-based landfill facilities from planned activities, a sensitivity rating of **High** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. As described in Section 9.1.5, Oil Spill Modeling Results, a likelihood rating of **Unlikely** for a marine oil spill and a coastal fuel spill is applied. Accordingly, the overall pre-mitigation risk to the Georgetown-based landfill component of waste management infrastructure capacity from a marine oil spill or coastal fuel spill is considered **Moderate** (see Table 9.19-1).

As described in Section 8.6, Waste Management Infrastructure Capacity, the Project has initiated a number of mitigation measures to ensure the Project (and all of EEPGL's operations) continue to have access to a reliable supply of waste management infrastructure capacity for its routine operations; these same mitigation measures would be directly applicable in the case of spill response-related waste management needs. With implementation of these mitigation measures, and considering that EEPGL has a robust plan for managing waste (i.e., through a combination of the OSRP and CWMP, as well as provisions for adapting these plans as needed based on the nature of the response effort), the intensity ratings for potential spill response-related impacts on waste management infrastructure capacity from a marine oil spill or coastal fuel spill would be reduced to **Low** for Georgetown-based hazardous waste treatment facilities and **Negligible** for Georgetown-based landfills.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low** for both Georgetown-based hazardous waste treatment facilities and Georgetown-based landfills. In combination with the likelihood rating of **Unlikely** for a marine oil spill and a coastal fuel spill, the residual risk to waste management infrastructure capacity from these types of unplanned events is considered **Minor** (see Table 9.19-1).

Table 9.19-1: Risk Ratings for Unplanned Event Impacts on Waste Management Infrastructure Capacity

Unplanned Event	Resource/Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill or Coastal Fuel Spill (response efforts)	Waste Management Infrastructure and Capacity (non-Project users of Georgetown-based hazardous waste treatment facilities)—exceedance of capacity	Unlikely	Low	Minor	As warranted based on anticipated future EEPGL waste generation trends and trends in non-EEPGL hazardous waste generation, continue enabling the expansion of existing local waste management capacity for hazardous wastes, and explore use of new local hazardous waste treatment facilities, or identify suitable alternative solutions.	Minor
Marine Oil Spill or Coastal Fuel Spill (response efforts)	Waste Management Infrastructure and Capacity (non-Project users of Georgetown-based landfill facilities)—exceedance of capacity	Unlikely	High	Moderate	Continue monitoring of plans for further expansion of the HBL and/or (if approved by the EPA) construction of additional landfill sites in other locations (as decided by the government), or identify suitable alternative (interim) local solutions for non-hazardous waste management.	Minor

9.20. CULTURAL HERITAGE

As indicated in Table 9.1-6, the only unplanned events with the potential to result in measurable impacts on cultural heritage would be a marine oil spill, a coastal fuel spill, or an NADF release. This section considers the risk to coastal cultural heritage, including submerged nearshore and deep-water, cultural heritage as a result of these potential unplanned events.

9.20.1. Marine Oil Spill

As noted in Section 8.7.2.2, Coastal Cultural Heritage, data obtained from the National Trust of Guyana show that there are several archaeological sites along the Guyana coast, including shell mounds, seashell deposits, quarries, pollen sections, tool/implements, and ceramic/pottery sites (i.e., scatters). In Regions 1 and 2, there are approximately 68 and 12 of these sites, respectively (EMC Personal Communication 6). Desktop research has identified two known ceramic/pottery sites nearest to the coastline. Additionally, Section 8.9.2, Existing Conditions—Ecosystem Services, describes cultural heritage sites identified by local community members during the late 2017 and early 2018 ecosystem services baseline data collection and 2019 validation efforts. In Region 1, these include shell mounds near Haimacobra Village, Waramuri Village, and Assakata Village, as well as a sacred site (a 200-year-old church) near Santa Rosa Village. In Region 2, a historic landmark (a Dutch chimney) in the Supenaam area was identified. In Region 3, identified historical sites included a monument and an eighteenth-century Dutch koker, both located near Best/Klien/Pouderoyen (ERM/EMC 2018). Based on the ubiquity of past human occupations (and thus archaeological sites), especially along coastlines, it is possible that there are additional unidentified archaeological resources along Guyana's coastline. In addition, a significant chance find of a shipwreck site (potential cargo ship) is present approximately 24.6 kilometers (15.3 miles) from the Yellowtail PDA. Other potential anthropogenic debris identified in southeast Stabroek Block was found to have no significant cultural value.

As described in Section 9.1.5, Oil Spill Modeling Results, stochastic oil spill modeling for the Most Credible WCD and Maximum WCD scenarios indicates a 5 to 40 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 1 and a 5 to 10 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 2. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain offshore of Guyana for the Most Credible WCD scenario and for the Maximum WCD (Jun-Nov) scenario. Deterministic modeling predicts impact across the majority of the Region 1 shoreline for the (Dec–May) Maximum WCD scenario. Modeling mitigation under this scenario predicts a reduction in the predicted length of shoreline impact in Region 1, but the predicted length still represents the majority of the Region 1 shoreline The deterministic modeling analysis does not predict shoreline impacts in Guyana outside of Region 1 for either the Most Credible WCD or Maximum WCD scenarios, regardless of season or the effects of mitigation.

If an unmitigated marine oil spill were to reach a Guyana shoreline, the spill would generally only impact the intertidal zone, unless the spill coincides with a significant storm surge. Additionally, while archaeological sites are common along coastlines, sites in the intertidal zone

tend to lack stratigraphic integrity due to the dynamic interface between the ocean and the land, especially along beaches. Should a marine spill reach the location of a shipwreck site, most of the spill impact would be to water quality at and near the surface. While water and sediment quality impacts at the seabed at a shipwreck site could occur, impacts to the site would be limited. Accordingly, the intensity of such an impact on coastal cultural heritage is considered **Low**.

The geographic extent of an unmitigated marine oil spill would include portions of the **Indirect AOI**. On the basis that the marine oil spill would continue over several weeks, the frequency is considered to be **Continuous**. Assuming no mitigation of the spill, the effects could extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity ratings assigned for potential impacts on coastal cultural heritage, a sensitivity rating of **Medium** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a marine oil spill is considered **Unlikely**, so the overall risk of a marine oil spill to coastal cultural heritage is considered **Minor**.

Effective implementation of the OSRP would further reduce the risk of an oil spill reaching the coast by limiting the geographic extent the oil could travel. Accordingly, the intensity of a marine oil spill on coastal cultural resources would be reduced to **Negligible**. The geographic extent of a mitigated marine oil spill would include portions of the **Indirect AOI**. On the basis that the impacts from a marine oil spill could persist over several weeks, the frequency is considered to be **Continuous**. The effects, assuming mitigation of the spill, would be reduced to less than a year, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Negligible**. Consistent with the sensitivity ratings assigned for potential impacts on coastal cultural heritage, a sensitivity rating of **Medium** is assigned. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.1.9, a marine oil spill is considered **Unlikely**, so the overall residual risk of a marine oil spill to coastal cultural heritage (see Table 9.20-1) remains as **Minor**.

9.20.2. Coastal Fuel Spill

A coastal fuel spill, if it were to occur, would likely happen in Regions 3 and 4 at or near the shorebases or near the mouth of the Demerara River. The coastline in this area is highly developed, significantly reducing the likelihood that coastal archaeological resources would be present at any locations where a coastal fuel spill resulted in an impact on the shoreline or onshore. No such resources were identified in the ecosystems services field validation work described above. However, sites along the shoreline in Region 3 have been identified to hold contemporary cultural heritage value, most notably as areas for prayer and burial/cremation rituals, where access to water and low levels of human activity are important attributes.

Accordingly, the intensity of a coastal fuel spill on coastal cultural resources is considered **Low**. The geographic extent of an unmitigated coastal fuel spill could include portions of the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal fuel spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity ratings assigned for potential impacts on coastal cultural heritage, a sensitivity rating of **Medium** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.1.9, a marine oil spill is considered **Unlikely**, so the overall risk of a marine oil spill to coastal cultural heritage is considered **Minor**.

While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of an impact on coastal cultural heritage from an oil spill, the residual risk rating remains **Minor**.

9.20.3. NADF Release

With respect to potential impacts on underwater cultural heritage, in the unlikely event of an NADF release, some oil would be expected to settle to the seafloor and could potentially impact a submerged cultural heritage site (e.g., shipwreck), if present. However, the probability for this to occur would be limited to the drill centers where such operations and product transfers would be performed. In addition, a 500-meter exclusion zone is associated with each drill center and a shallow hazard assessment is conducted prior to any drilling operations to verify the absence of such cultural heritage sites and other hazards. Based on geophysical surveys conducted in the PDA and surrounding vicinity, one shipwreck was identified; however, this site is located 24.6 kilometers (15.3 miles) from the PDA (see Section 8.7.2.1, Underwater Cultural Heritage). Based on these factors, the intensity of an NADF release with respect to impacts on underwater cultural heritage is therefore considered **Low**.

The geographic extent of an unmitigated NADF release to underwater cultural heritage would be limited to the **Direct AOI**. On the basis that impacts from an unmitigated NADF release would persist as long as cultural heritage sites were exposed to the spilled material, the frequency is considered to be **Continuous**. Even without mitigation, the currents would redistribute the spilled material and impacts would be expected to persist less than a year, yielding a **Medium-term** duration. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity ratings assigned for potential impacts on underwater cultural heritage, a sensitivity rating of **Medium** is assigned.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.1.9, an NADF release is considered **Unlikely**, so the overall risk of an NADF release to underwater cultural heritage is

considered **Minor** (see Table 9.20-1). While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of an impact on underwater cultural heritage from an oil spill, the residual risk rating remains **Minor**.

Table 9.20-1: Risk Ratings for Unplanned Event Impacts on Cultural Heritage

Unplanned Event	Resource	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Coastal Cultural Heritage	Unlikely	Low	Minor	Implement OSRP	Minor
Coastal Fuel Spill	Coastal Cultural Heritage	Unlikely	Low	Minor	Implement OSRP	Minor
NADF Release	Marine Cultural Heritage	Unlikely	Low	Minor	Implement OSRP	Minor

9.21. LAND USE

As indicated in Table 9.1-6, the only unplanned events with the potential to result in measurable impacts on land use would be a marine oil spill or a coastal fuel spill. The principal concerns with respect to potential land use impacts from a marine oil spill or coastal fuel spill relate to the scenarios where a spill would affect a portion of the shoreline being used for agricultural purposes (e.g., subsistence farming or livestock) or where a spill could indirectly result in adverse impacts on land drainage (i.e., through sluice closures). Accordingly, the assessment of potential impacts on land use from unplanned events is focused on these two scenarios. In the unlikely event of a spill, short-term land use value impairment would be addressed via EEPGL's grievance redress and livelihood remediation processes; long-term impairment will be avoided using the shoreline cleanup process, and impacts that cannot be remediated will be subject to other forms of redress or compensation. Shoreline cleanup would be applied via the three-phase cleanup process described in the OSRP.

As described in Section 9.1.10.1, Vessel Collision with a Third-Party Vessel or Structure (Non-Spill Related Impacts), if a coastal fuel spill were to occur at the shorebases or as a result of the nearshore grounding of a vessel or a vessel collision, marine diesel could enter the Georgetown Harbour / Demerara River estuary. As shown on Figure 9.21-1, there are only a few areas along the shore zone or coastal areas near Georgetown and on the western bank of the Demerara River bank that are used for agricultural purposes—specifically, subsistence farming and/or grazing of livestock. As shown on the figure, these areas are set back from the coast and protected by either manmade structures (e.g., seawall) or mangroves. A potential coastal fuel spill would only affect land use in these areas if it occurred in proximity to one of the sites, were sufficiently large to reach the shoreline, and the tide was sufficiently high at the time of the spill to carry the spill over the bank and onto the sites in question.

9.21.1. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, stochastic oil spill modeling for the Most Credible WCD and Maximum WCD scenarios indicates a 5 to 40 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 1 and a 5 to 10 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 2. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain offshore of Guyana for the Most Credible WCD scenario and for the Maximum WCD (Jun-Nov) scenario. Deterministic modeling predicts impact across the majority of the Region 1 shoreline for the (Dec–May) Maximum WCD scenario. Modeling mitigation under this scenario predicts a reduction in the predicted length of shoreline impact in Region 1, but the predicted length still represents the majority of the Region 1 shoreline. The deterministic modeling analysis does not predict shoreline impacts in Guyana outside of Region 1 for either the Most Credible WCD or Maximum WCD scenarios, regardless of season or the effects of mitigation.

The area of potential effect in this scenario includes the SBPA in Region 1, where only a few plots of land are used for agricultural purposes along or in close proximity to the coast, specifically at Father's Beach and Almond Beach (see Figure 9.21-2). In Region 2, crop cultivation is present in many communities along the coast (including but not limited to Charity/Urasara, Evergreen/Paradise, Anna Regina, and Good Hope/Pomona) and ranges in scale from subsistence farming of rice and other staple grains, to export-oriented cash crops of coconuts and watermelons (see Figure 9.21-3). Similarly, spilled oil that reaches the river systems could end up in these farming areas.

A marine oil spill would only affect these areas if it were sufficiently large to reach these areas along the shoreline, and the tide was sufficiently high at the time of the spill to carry the spill onto the sites in question. As described in Section 9.15, Socioeconomic Conditions / Employment and Livelihoods, these impacts are considered highly unlikely, but could affect subsistence and/or commercial farming in coastal areas. Accordingly, the intensity of a marine oil spill with respect to potential impacts on land use for agricultural purpose is considered to be **Medium**.

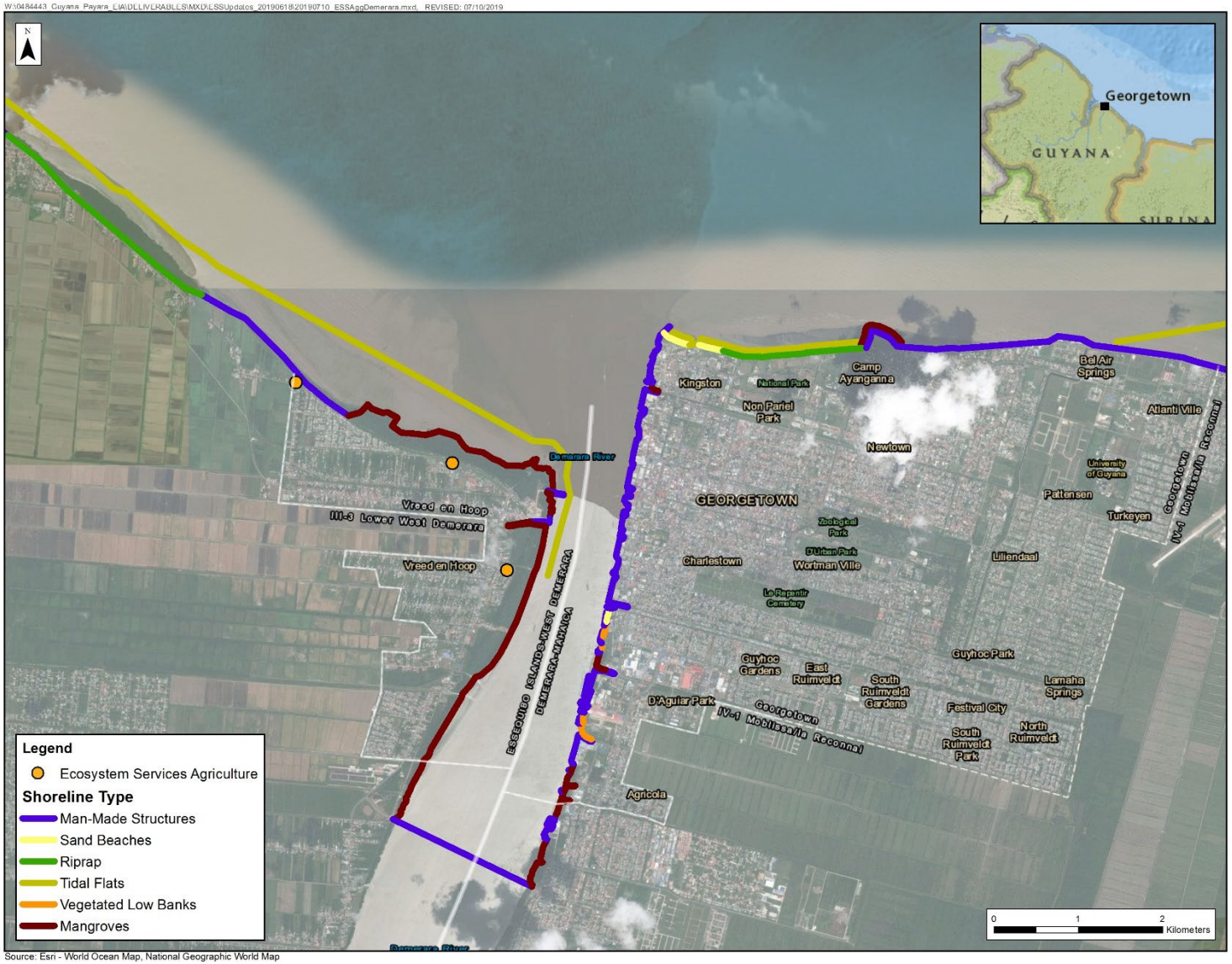


Figure 9.21-1: Agricultural Areas along the Coast in Georgetown / Demerara River Vicinity

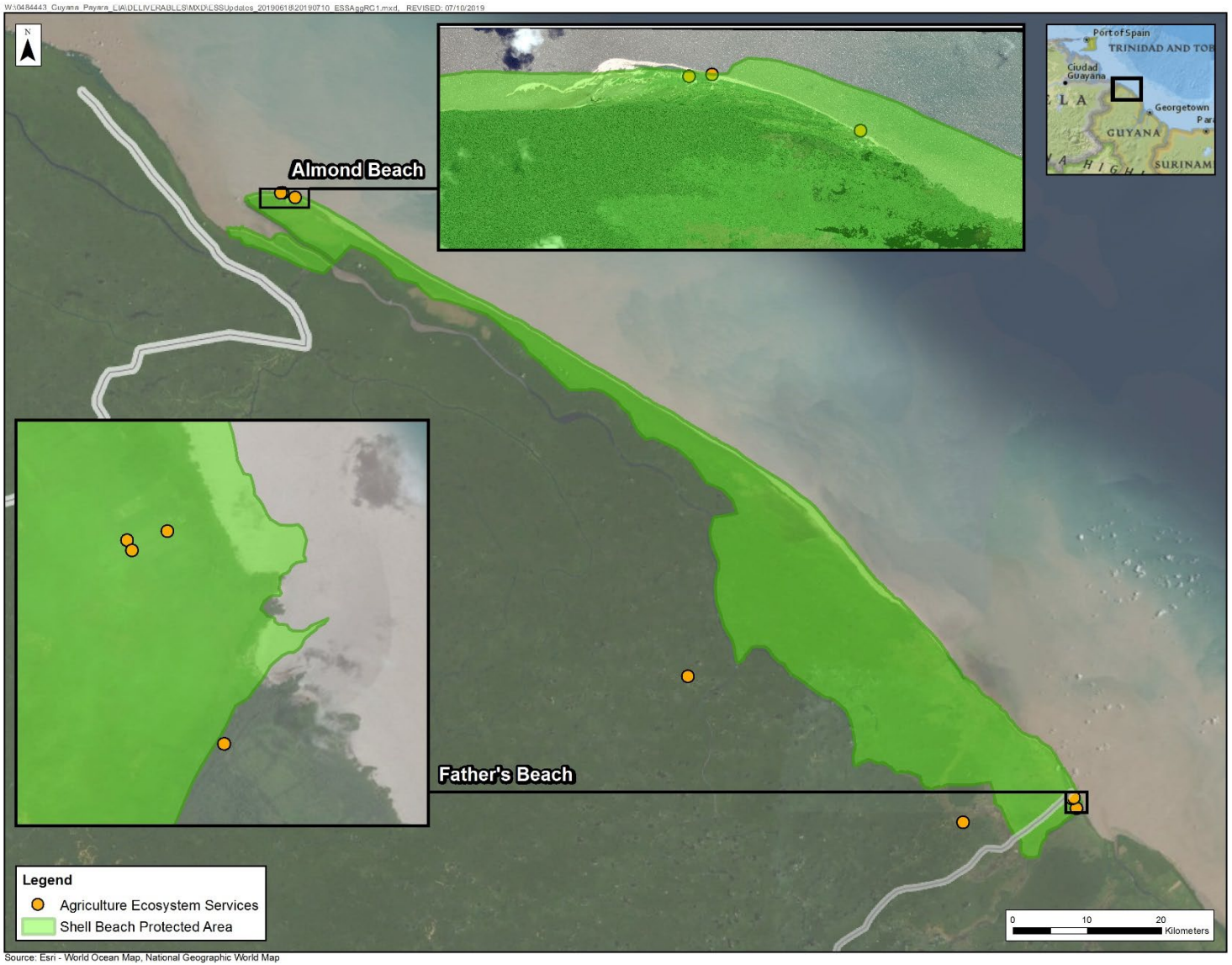
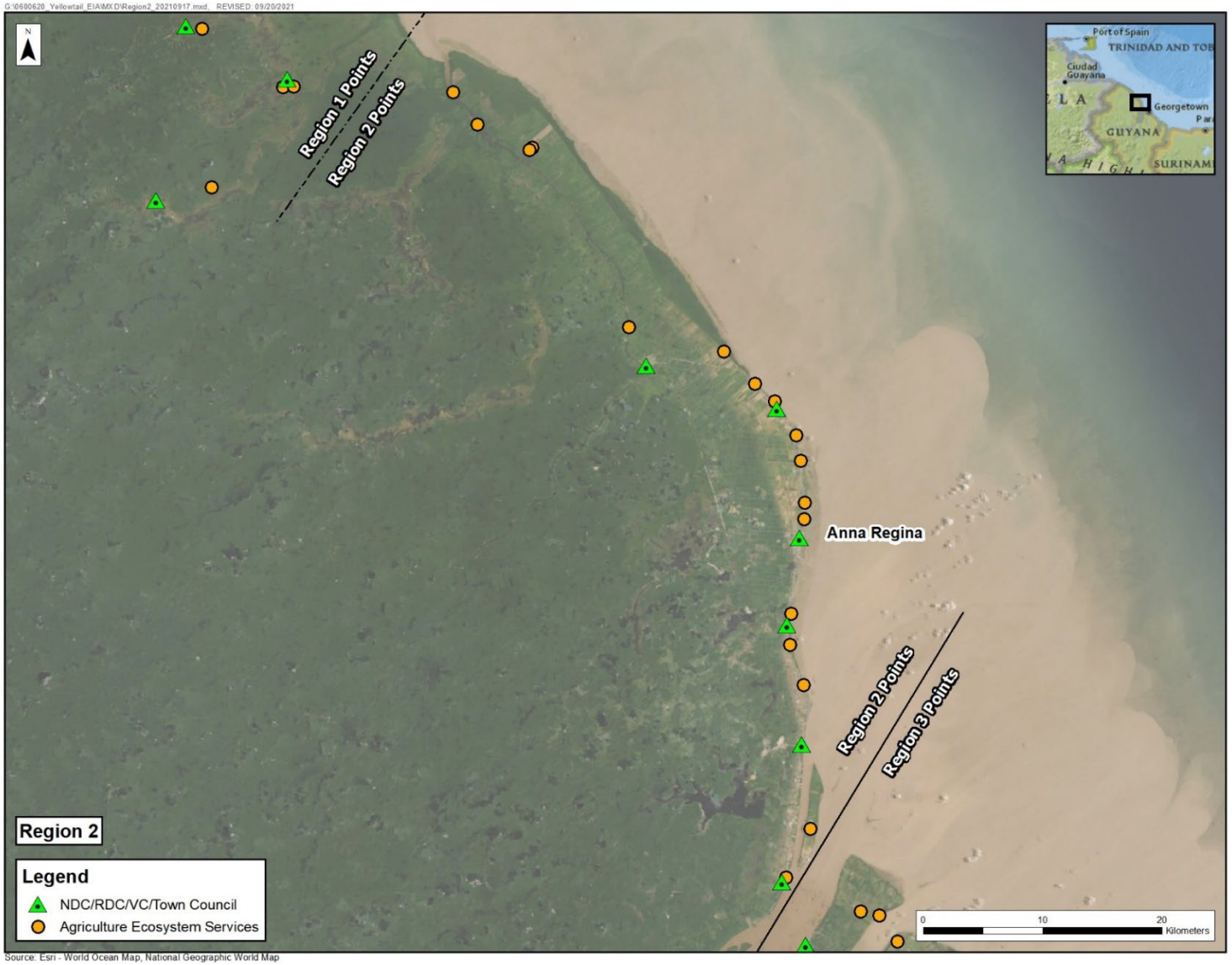


Figure 9.21-2: Agricultural Areas along the Coast in Region 1



NDC = Neighbourhood Democratic Council; RDC = Regional Democratic Council; VC = Village Council

Figure 9.21-3: Agricultural Areas along the Coast in Region 2

The geographic extent of a marine oil spill would include portions of the **Indirect AOI**. In the absence of mitigation, impacts from a marine oil spill could persist over a multi-week basis, so the frequency is considered to be **Continuous**. Depending on the size of the spill, the effects, assuming no mitigation of the spills, would have the potential to extend beyond a year, so duration is conservatively considered to be **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**. Consistent with the sensitivity ratings assigned for potential impacts on land use from planned activities, a sensitivity rating of **Medium** is assigned assuming that the impact would affect land used for income generation.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the risk to land use from this unplanned event is considered **Moderate** (see Table 9.21-1).

As discussed in Section 9.15, the mitigation measures of OSRP implementation would serve to considerably reduce the intensity of such an impact from a marine oil spill to **Low**. Response measures would also reduce the duration of effects to more than a week but less than a year, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**. The sensitivity rating of **Medium** is maintained and the residual risk rating is determined to be **Minor**.

9.21.2. Coastal Fuel Spill

Depending on tidal conditions and extent of spread of the spill, a coastal fuel spill also could prevent the opening up of sluices to allow for drainage of lands along the Demerara River. Closure of sluices could prevent the spill moving inland into canals, but if such closure happens in the rainy season, it could affect area drainage and lead to water accumulation on lands and flooding as a result. However, if this were to occur, the limitation on opening sluices would be expected to be short-term in nature, reducing the consequence from a flooding perspective.

Based on the factors above, the intensity of a coastal fuel spill with respect to potential impacts on land use for agricultural purpose is considered to be **Low**.

The geographic extent of an unmitigated coastal fuel spill would include portions of the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal fuel spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity ratings assigned for potential impacts on land use from planned activities, a sensitivity rating of **Medium** is assigned assuming that the impact would affect land used for income generation.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.5, Oil Spill Modeling Results, a coastal fuel spill is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to land use from this unplanned event is considered **Minor** (see Table 9.21-1). While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of an impact on land use from a coastal fuel spill, the residual risk rating is maintained at **Minor**.

Table 9.21-1: Risk Ratings for Unplanned Event Impacts on Land Use

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Land Use	Unlikely	High	Moderate	Implement OSRP	Minor
Coastal Fuel Spill	Land Use	Unlikely	Low	Minor	Implement OSRP	Minor

9.22. ECOSYSTEM SERVICES

As indicated in Table 9.1-6, the unplanned events with the potential for any measurable impacts on ecosystem services would be a marine oil spill and a coastal fuel spill. This section considers potential impacts on provisioning, regulating, and cultural ecosystem services in relation to marine oil spill and coastal fuel spill scenarios.

As described in Section 9.1.5, Oil Spill Modeling Results, stochastic oil spill modeling for the Most Credible WCD and Maximum WCD scenarios indicates a 5 to 40 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 1 and a 5 to 10 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 2. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain offshore of Guyana for the Most Credible WCD scenario and for the Maximum WCD (Jun–Nov) scenario. Deterministic modeling predicts impact across the majority of the Region 1 shoreline for the (Dec–May) Maximum WCD scenario. Modeling mitigation under this scenario predicts a reduction in the predicted length of shoreline impact in Region 1, but the predicted length still represents the majority of the Region 1 shoreline. The deterministic modeling analysis does not predict shoreline impacts in Guyana outside of Region 1 for either the Most Credible WCD or Maximum WCD scenarios, regardless of season or the effects of mitigation.

As described in Section 9.21, Land Use, depending on the location of a coastal fuel spill, marine diesel could enter the Georgetown Harbour / Demerara River estuary, potentially affecting coastal ecosystem services in Regions 3 and 4. For these reasons, the discussion of potential impacts on ecosystem services is focused on Regions 1 and 2 (in the case of a marine oil spill) and Regions 3 and 4 (in the case of a coastal fuel spill). Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

9.22.1. Potential Ecosystem Services Receptors and Impacts

Guyana is a country that is rich in natural resources and a large proportion of the population still relies on these resources for livelihoods and subsistence. Fisheries and agriculture are still among the top contributors to the country's gross domestic product, and these activities occur primarily in the coastal areas. The Region 2 and 3 economies derive a large share of their income from farming, with rice being predominant in Region 2 and rice and sugarcane being predominant in Region 3. Populations in these regions also grow many non-traditional crops for local sale and consumption. In Region 1, agriculture occurs at a relatively small scale—for subsistence use mainly—but a number of other natural resource–based activities take place, particularly by indigenous communities. Along the coast and at the river mouths, these activities include fishing, crabbing, hunting, and trapping. Some communities also hunt shorebirds, wild animals, and marine turtles, and collect marine turtle eggs and medicinal plants from the Shell Beach area. While the Region 4 economy is more diverse compared to the other coastal regions, there is still a large fishing sector and considerable agricultural activity in the rural parts of the region.

Other provisioning services that could be potentially impacted by an unmitigated marine oil spill include the coastal transportation networks that link communities and provide access to markets, especially in Region 1 and between Regions 2 and 3, where aquatic transportation is the only method of transportation available.

In addition to provisioning services, the marine and coastal ecosystems in Guyana provide a range of other important services that offer protection, and are necessary for the functioning and support of ecosystems and both human and non-human life. These include regulating services such as the coastal flood protection offered by mangrove forests and wildlife habitat provided by mangrove forests, mud banks, and coastal swamps.

In terms of cultural services, areas along the coast in Regions 2 through 4 are important for religious and traditional ceremonies for ethnic groups in Guyana. Many members of the Hindu community conduct funeral ceremonies on the seashore, with disposal of ashes in the ocean. Throughout the year and during holy festivals, Hindus also perform cleansing ceremonies on the seashore. African cultural organizations perform traditional emancipation ceremonies at a specific seawall location in the Georgetown area once a year. Additionally, seawalls, beaches, and coastal parks are important to locals for tourism, recreation, and leisure.

Table 9.22-1 provides a summary of the potential ecosystem services impacts that could result from a marine oil spill or a coastal fuel spill.

Table 9.22-1: Potential Ecosystem Services Receptors and Impacts from a Marine Oil Spill or Coastal Fuel Spill

Receptor(s)	Key Potential Impacts
Coastal population in Regions 2, 3, 4	• Impacts on commercial fisheries and subsistence fishing • Impacts on coastal agriculture (subsistence farming and non-traditional crops, e.g., coconut, palm hearts) and grazing of animals • Impacts on aquatic transportation systems and trade • Impacts on shoreline protection provided by mangroves • Impacts on recreation, leisure, and tourism
Hindu population in Regions 2, 3, 4	• Disruption of religious ceremonies (funeral and cleansing ceremonies)
Coastal population in Region 1, predominately Indigenous Peoples	• Impacts on agriculture, fishing, crabbing, hunting, trapping • Impacts on shoreline protection provided by river mangroves • Impacts on mangroves on Shell Beach • Impacts on aquatic transportation systems and trade • Impacts on (burgeoning) ecotourism

This section provides an assessment of potential impacts on ecosystem services, with reference to related assessments in Sections 9.15, Socioeconomic Conditions / Employment and Livelihoods, 9.17, Marine Use, 9.20, Cultural Heritage, and 9.21, Land Use.

9.22.2. Definitions for Intensity of Impact and Sensitivity of Receptor

Definitions for intensity of impact and sensitivity of receptor were not provided in the assessment of potential impacts on ecosystem services from planned Project activities because there are no potential impacts on ecosystem services from planned Project activities. Because the methodology for determining a rating for risks to ecosystem services from an unplanned event involves consideration of the intensity of impact (assuming the unplanned event were to occur) and sensitivity of receptor, they are therefore provided in this section.

The intensity of potential impacts on ecosystem services is defined according to the definitions provided in Table 9.22-2.

Table 9.22-2: Definitions for Intensity Ratings for Potential Impacts on Ecosystem Services

Criterion	Definition
Intensity	Negligible: No changes to ecosystem services functions and values.
	Low: Changes to function(s) and/or value(s) of ecosystem services, but limited to a localized area.
	Medium: Changes to function(s) and/or value(s) of ecosystem services over a moderately sized area.
	High: Widespread changes to function(s) and/or value(s) of ecosystem services.

The sensitivity of ecosystem services to individuals and households is defined according to the definitions provided in Table 9.22-3.

Table 9.22-3: Definitions for Sensitivity Ratings for Potential Impacts on Ecosystem Services

Criterion	Definition
Sensitivity	Low: Individuals and/or households are not highly dependent on the benefits obtained from any one critical or high-rated ecosystem service (or its location), and can recover quickly from Project-related impacts to such ecosystem service(s).
	Medium: Individuals and/or households cannot readily recover from Project-related impacts to a critical or high-rated ecosystem service(s), but can take advantage of benefits resulting from other ecosystem service(s) or economic/recovery opportunities.
	High: Individuals and/or households cannot readily recover from Project-related impacts to a critical or high-rated ecosystem service(s), and that ecosystem service(s) represents a substantial fraction of an ecosystem service type.

9.22.3. Marine Oil Spill

As noted above, for both loss-of-well-control scenarios modeled, stochastic oil spill modeling for the Most Credible WCD and Maximum WCD scenarios indicates a 5 to 40 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 1 and a 5 to 10 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 2. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain offshore of Guyana for the Most Credible WCD scenario and for the Maximum WCD (Jun–Nov) scenario, but would impact across the majority of the Region 1 shoreline for the Maximum WCD (Dec–May) scenario. Deterministic modeling also predicts that a mitigated spill would impact a shorter predicted length of shoreline in Region 1, but the predicted length still represents the majority of the Region 1 shoreline. However, deterministic modeling analysis does not predict shoreline impacts in Region 2 (or other Guyana regions outside of Region 1), for either the Most Credible WCD or Maximum WCD scenarios, regardless of season or the effects of mitigation. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

As described in Section 9.23, Indigenous Peoples, indigenous communities in remote areas of Region 1 rely on coastal habitats for subsistence and livelihoods and have fewer alternative food sources and livelihood opportunities. In the unlikely event of a marine oil spill reaching the coast, provisioning ecosystem resources in Region 1 could potentially be adversely impacted. In the event that mangrove forests and swamps along the coast are impacted by an oil spill, species such as fish, crabs, birds, and wild animals (iguanas, deer, wild hog, agouti, labba, etc.), which are depended upon by indigenous communities as a source of protein, would potentially be impacted.

Crabbing and fishing (but especially crabbing) sites are particularly widespread across the entirety of Region 1's coastline, whereas hunting areas are most densely concentrated in the northwest corner of Region 1, around the Waini River. The area around the Waini River provides a particularly diverse set of ecosystem services including crabbing, fishing, hunting areas, mangroves, agricultural areas, and traditional/religious sites. The area surrounding the boundary between Regions 1 and 2 is similarly important, although there are a higher number of traditional/religious sites in this area than in the far northwestern portion of Region 1. Agriculture is also slightly more important in this area than in the far northwestern portion of Region 1.

Between these two extremes, in the middle portion of Region 1's coast, crabbing is the most prevalent ecosystem service, with general biodiversity, foraging/gathering sites, and traditional/social sites playing a less important role.

In Region 2, coastal agriculture including livestock and crop cultivation is present in many communities along the coast (including but not limited to Charity/Urasara, Evergreen/Paradise, Anna Regina, and Good Hope/Pomona) and ranges in scale from subsistence farming of rice and other staple grains, to export-oriented cash crops of coconuts and watermelons. The shoreline of Region 2 also provides ecosystem services including locations for fishing, trapping/hunting, social and cultural practices, and—to a lesser degree—some crabbing, ecotourism,

Therefore, with respect to provisioning ecosystem services, the key concerns would be potential impacts on fishing and crabbing from an unmitigated marine oil spill, especially if the oil reaches near-coastal waters (where most artisanal and commercial fishing occurs). Potential impacts on trapping and hunting would also be a concern, especially in the area around the Waini River and along the shoreline of Region 2. In Region 2 and the southeastern portion of Region 1, effects on agricultural and cultural/religious activities could be of concern. Impacts on the growing ecotourism sector in some villages in Region 1, most notably Warapoka, could also be of concern, as a marine oil spill could discourage tourists from visiting the region.

9.22.3.1. Fisheries Resources and Aquatic Transportation

If oil were to reach near-coastal waters where most fishing occurs, the intensity of a marine oil spill with respect to potential impacts on fisheries resources and aquatic transportation is considered to be **Medium**.

The geographic extent of an unmitigated marine oil spill would include portions of the **Indirect AOI** including shoreline in Region 1 and Region 2. On the basis that impacts from an unmitigated marine oil spill could persist over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming no mitigation of the marine oil spill, would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**.

With a largely indigenous and rural population, individuals and households within Region 1, and (to a degree) Region 2, typically have a higher vulnerability to change and derive significant benefit from fisheries resources and aquatic transportation for their livelihoods. While the ecosystem provisioning service of cultivating crops is also of critical benefit, that service could not replace the benefits derived from fishing and aquatic transport. Consistent with the sensitivity rating definitions in Table 9.22-3, individuals and households within Regions 1 and 2 are assigned a sensitivity rating of **High**. Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. As described in Section 9.1.5, Oil Spill Modeling Results, a marine oil spill is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to fisheries resources and aquatic transportation from an unmitigated marine oil spill is considered **Moderate**.

In the unlikely event of a marine oil spill, EEPGL will deploy emergency response equipment to mitigate the effects of the spill and to protect sensitive coastal resources such as mangroves, as appropriate. Effective implementation of the OSRP would reduce this risk by reducing the probability of oil reaching near-coastal waters or the Guyana coast. Additionally, a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established to further reduce this risk by compensating for livelihoods affected as a result of effects on fisheries-related ecosystem services or effects on other nearshore provisioning services (e.g., should mobility of transport and access to markets via aquatic networks be impacted). On this basis, the residual risk rating is reduced to **Minor**.

9.22.3.2. Coastal Agriculture

With respect to potential impacts on coastal agriculture in Region 1 and Region 2, in the unlikely event of an unmitigated marine oil spill, stochastic modeling indicates the potential for subsistence farming along the SBPA in Region 1 and the shoreline of Region 2 to be impacted. In Region 1, only a few plots of land used for agricultural purposes along or in close proximity to the coast, specifically Father's Beach and Almond Beach. Furthermore, there are only a few coastal areas where hunting and trapping occur. However, the shoreline in Region 2 involves a number of locations identified for coastal agriculture, stretching from the Essequibo River to north of Anna Regina, and in the north of the region near the border with Region 1. A marine oil spill would only directly affect these areas if it were sufficiently large enough to reach these areas along the shoreline and the tide was sufficiently high at the time of the spill to carry the spill onto the sites in question.

In some coastal communities, such as Three Brothers, Smith's Creek, and Morawhanna, river water occasionally overflows the empoldered areas created for farming, resulting in salt-water intrusion. Similarly, spilled oil that reaches the river systems could potentially end up in these farming areas. These effects are considered highly unlikely, as the movement of oil upstream would be limited by tidal action. Further, farmers would have ample notice to close sluice gates, and spill responders would have time to install absorbent booms or other spill control equipment to prevent oil from reaching farmers' crops or drainage inlets. Therefore, the intensity of the potential impact on coastal agriculture would be **Low**.

The geographic extent of an unmitigated marine oil spill would include portions of the **Indirect AOI**. On the basis that impacts from an unmitigated marine oil spill could persist over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming no mitigation of the marine oil spill, would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity rating definitions in Table 9.22-3, individuals and households within Regions 1 and 2, who typically have a higher vulnerability to change and value agricultural ecosystem services as critical, are assigned a sensitivity rating of **High**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 9.1.5, Oil Spill Modeling Results, a marine oil spill is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to coastal agriculture from a marine oil spill is considered **Minor**.

Effective implementation of the OSRP would reduce this risk by reducing the probability of oil reaching near-coastal waters or the Guyana coast. Additionally, a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established to further reduce this risk by compensating economic losses related to loss of these provisioning services. While these mitigation measures would considerably reduce the risk of impacts from a marine oil spill, the residual risk rating is maintained at **Minor**.

9.22.3.3. Shoreline Protection

With respect to regulating ecosystem services, specifically shoreline protection, in the unlikely event of a marine oil spill reaching the coast, important habitats such as mangrove forests, mud flats, swamps, and beaches could be impacted. These provide a range of ecosystem services to coastal populations in Region 1. If oiling is severe enough to cause the loss of some mangrove forests, this would weaken a critical component of the country's sea defense system and expose the coastal population to increased coastal flooding hazard, especially in Region 1, where agricultural areas are not protected from flooding by the same system of sea defense as in Regions 2 through 6. On this basis, the intensity of a marine oil spill with respect to potential impacts on shoreline protection in Region 1 is considered **Medium**.

The geographic extent of an unmitigated marine oil spill would include portions of the **Indirect AOI**. On the basis that impacts from an unmitigated marine oil spill could persist over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming no mitigation of the marine oil spill, would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Large**. Consistent with the sensitivity rating definitions in Table 9.22-3, individuals and households within Region 1 who typically have a higher vulnerability to change and would be impacted by the coastal flooding hazard are assigned a sensitivity rating of **High**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High.** As described in Section 9.1.5, a marine oil spill is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to shoreline protection-related ecosystem services from this unplanned event is considered **Moderate**.

In the unlikely event of a marine oil spill, EEPGL will deploy emergency response equipment to mitigate the effects of the spill and to protect sensitive coastal resources such as mangroves, as appropriate. Effective implementation of the OSRP would reduce this risk by reducing the probability of oil reaching near-coastal waters or the Guyana coast. On this basis, the residual risk rating is reduced to **Minor**.

9.22.3.4. Ecotourism

During the 2019 ecosystem services validation field efforts, village leaders in Warapoka described increased ecotourism in their village as a result of targeted efforts by the village and regional government to build ecotourism opportunities in the area. Other villages, such as Waramuri and Assakata, also indicated their plans to build ecotourism-related infrastructure. Areas in Region 1, especially Warapoka and the SBPA, have high aesthetic and educational value—and constitute an important cultural ecosystem service. Although the global COVID-19 pandemic has affected travel and tourism around the world since 2020, the ecotourism prospects of these communities are acknowledged.

In the unlikely event of a marine oil spill reaching the Guyana coast, ecotourism could be impacted. However, ecotourism in SBPA is not prevalent and the prospect of an oil spill deterring tourists from visiting Warapoka would therefore be minimal. Accordingly, the intensity of a marine oil spill with respect to potential impacts on ecotourism in Region 1 is considered **Low**.

The geographic extent of an unmitigated marine oil spill would include portions of the **Indirect AOI**. On the basis that impacts from an unmitigated marine oil spill would continue over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming no mitigation of the marine oil spill, would have the potential to extend beyond a year, so duration is considered to be **Long-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**. For these villages that benefit from ecotourism, there are no other critical or high-rated ecosystem cultural services that could replace ecotourism. For this reason, and consistent with the sensitivity rating definitions in Table 9.22-3, individuals and households within Region 1—who typically have a higher vulnerability to change—are assigned a sensitivity rating of **High**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium.** As described in Section 9.1.5, a marine oil spill is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to ecotourism from this unplanned event is considered **Minor**. While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of such an impact from a marine oil spill, the residual risk rating is maintained at **Minor**.

9.22.4. Coastal Fuel Spill

9.22.4.1. Fishing and Aquatic Transportation

An unmitigated coastal fuel spill would likely only happen near the shorebases that would be used by the Project, which are located near the mouth of the Demerara River. Therefore, depending on the location, a coastal fuel spill could potentially affect coastal ecosystem services associated with the Demerara River estuary and adjacent shoreline in Regions 3 and 4. Fisheries services are critical ecosystem provisioning services in both of these regions, and aquatic transportation is also a critical ecosystem provisioning service in Region 3. Therefore,

the intensity of a coastal fuel spill with respect to potential impacts on fisheries resources and aquatic transportation is considered to be **Medium**.

The geographic extent of an unmitigated coastal fuel spill could include portions of the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather), and because the impacts of an unmitigated coastal fuel spill could—depending on the volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**. Consistent with the sensitivity rating definitions in Table 9.22-3, individuals and households within the affected regions would have a sensitivity rating of **High**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. As described in Section 9.1.5, a coastal fuel spill is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to provisioning ecosystem services related to fishing or other economic uses of affected coastal waterways from a coastal fuel spill is considered **Moderate**.

Effective implementation of the OSRP would reduce this risk by reducing the area affected by such a spill. Additionally, a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9) would be established to further reduce this risk by compensating affected fisherfolk for loss of harvest due to regional fisheries closures attributed to the oil spill, as well as other affected stakeholders (e.g., should mobility of transport and access to markets via aquatic networks be impacted). On this basis, the residual risk rating is reduced to **Minor**.

9.22.4.2. Coastal Agriculture

Depending on the location of a coastal fuel spill, marine diesel could enter the Georgetown Harbour/Demerara River estuary. There are only a few areas along the shore zone or coastal areas near Georgetown and on the western bank of the Demerara River bank that are used for agricultural purposes—specifically, subsistence farming and/or grazing of livestock in Region 3. These areas are set back from the coast and protected by either manmade structures (e.g., seawall) or mangroves. A potential coastal spill would only affect land use in these areas if it occurred in proximity to one of the sites, were sufficiently large to reach the shoreline, and the tide was sufficiently high at the time of the spill to carry the spill over the bank and onto the sites in question.

Rice farming, which makes up the majority of agricultural activity in the coastal area of Region 3, would not be directly impacted by a coastal fuel spill since rice fields are irrigated from inland water conservancies. However, the islands at the mouth of the Essequibo River, including Leguan and Wakenaam, use freshwater from the river for irrigation of rice crops. It is unlikely that a coastal fuel spill in the vicinity of Georgetown Harbour would reach the Essequibo River area. Therefore, the intensity of a coastal fuel spill with respect to potential impacts on coastal agriculture is considered to be **Low**.

The geographic extent of an unmitigated coastal fuel spill could include portions of the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal fuel spill could—depending on the volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology in Chapter 4, these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity rating definitions in Table 9.22-3, individuals and households within the affected regions who rely on these ecosystem services typically have the means to seek benefits from other critical or high-rated ecosystem services, and therefore have a sensitivity rating of **Medium**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.5, a coastal fuel spill is considered **Unlikely**. Accordingly, the overall pre-mitigation risk of a coastal fuel spill that reaches the Guyana coast on coastal agricultural-related ecosystem services communities is considered **Minor**.

In the unlikely event of a coastal fuel spill, the spill would be quickly controlled and contained because of the smaller volumes and the ready access to spill control equipment. There is the potential for a spill in these coastal areas to impact fisherfolk because of its proximity to nearshore fishing grounds. The affected area would be limited and of short duration, and a relatively rapid environmental recovery would be expected. Effective implementation of the OSRP would reduce this risk by reducing the area affected by such a spill. Additionally, a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9) would be established to further reduce this risk by compensating for economic losses. While these mitigation measures would considerably reduce the risk of impacts from a coastal fuel spill, the residual risk rating is maintained at **Minor**.

9.22.4.3. Shoreline Protection

With respect to shoreline protection, in the event of a coastal fuel spill, important habitats such as mangrove forests, mud flats, swamps, and beaches could be impacted. However, agricultural areas in Regions 3 and 4 are better protected by manmade sea defense systems than in Region 1. On this basis, the intensity of a coastal fuel spill with respect to potential impacts on shoreline protection in Region 3 and 4 is considered **Low**.

The geographic extent of an unmitigated coastal fuel spill could include portions of the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal fuel spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity ratings assigned in Table 9.22-3, individuals and households in the affected regions

would be impacted by a change in shoreline protection or sea defense systems but would have the ability to adapt and therefore have a sensitivity rating of **Medium**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Minor**. As described in Section 9.1.5, a coastal fuel spill is considered **Unlikely**. Accordingly, the overall (pre-mitigated) risk to shoreline protection-related ecosystem services from this unplanned event is considered **Minor**. While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of such an impact from a coastal fuel spill, the residual risk rating is maintained at **Minor**.

9.22.4.4. Recreation and Tourism

With respect to potential impacts on recreation and tourism, in the unlikely event of a coastal fuel spill reaching the coast, recreational uses of coastline areas could be impacted. Based on the high prevalence of use of most of the coastline for recreation and local tourism on a consistent basis, the intensity of such an impact is considered **Medium**.

The geographic extent of an unmitigated coastal fuel spill could include portions of the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal fuel spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology in Chapter 4, these characteristics lead to a magnitude rating of **Medium**. Consistent with the sensitivity ratings assigned in Table 9.22-3, individuals and households who would be impacted could find alternate locations and therefore have a sensitivity rating of **Low**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.5, a coastal fuel spill is considered **Unlikely**. Accordingly, the pre-mitigation risk to local tourism and recreation-related ecosystem services from this unplanned event is considered **Minor**. While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of such an impact from a coastal fuel spill, the residual risk rating is maintained at **Minor**.

9.22.4.5. Religious Ceremonies

With respect to potential impacts on traditional use and religious ceremonies, in the unlikely event of a coastal fuel spill reaching the coast, use of coastline areas for religious purposes could be impacted. Based on the use of the coastline for traditional and religious services, and the large Hindu population in the potentially affected coastal regions, the intensity of such an impact is considered **Medium**.

The geographic extent of an unmitigated coastal fuel spill could include portions of the **Indirect AOI**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled diesel fuel continued to weather) and because the impacts of an unmitigated coastal fuel spill could—depending on volume of release—continue over a several-week basis, the frequency and duration are

considered to be **Continuous** and **Medium-term**. Applying the methodology in Chapter 4, these characteristics lead to a magnitude rating of **Medium**. Consistent with the sensitivity ratings assigned in Table 9.22-3, individuals and households who would be impacted could find alternate locations and therefore have a sensitivity rating of **Low**.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Low**. As described in Section 9.1.5, a coastal fuel spill is considered **Unlikely**. Accordingly, the pre-mitigation risk to religious use–related ecosystem services from this unplanned event is considered **Minor**. While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of such an impact from a coastal fuel spill, the residual risk rating is maintained at **Minor**.

Table 9.22-4 summarizes the pre-mitigation and residual risks to ecosystem services from unplanned events.

Table 9.22-4: Risk Ratings for Potential Unplanned Event Impacts on Ecosystem Services

Unplanned Event	Ecosystem Service	Likelihood of Event	Consequence/ Severity Rating	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill (Region 1 and/or 2)	Fishing and aquatic transport	Unlikely	High	Moderate	Implement OSRP	Minor
	Coastal agriculture, trapping hunting	Unlikely	Medium	Minor	Implement claims and/or livelihood remediation processes for affected individuals	Minor
	Ecotourism	Unlikely	Medium	Minor		Minor
	Shoreline protection	Unlikely	High	Moderate	Implement OSRP	Minor
Coastal Fuel Spill (Region 3 or 4)	Fishing and aquatic transport	Unlikely	High	Moderate	Implement OSRP	Minor
	Coastal agriculture	Unlikely	Low	Minor	Implement claims and or livelihood remediation processes for affected individuals	Minor
	Shoreline protection	Unlikely	Low	Minor	Implement OSRP	Minor
	Recreation	Unlikely	Low	Minor		Minor
	Religious ceremonies	Unlikely	Low	Minor		Minor

9.23. INDIGENOUS PEOPLES

As indicated in Table 9.1-6, the only unplanned event with the potential to result in measurable impacts on Indigenous Peoples would be a marine oil spill. A coastal fuel spill, if it were to occur, would likely happen at or near the shorebases or near the mouth of the Demerara River. Significant indigenous populations are not present in this area; accordingly, potential risk to Indigenous Peoples from a coastal fuel spill is not discussed further herein.

As described in Section 9.1.5, Oil Spill Modeling Results, stochastic oil spill modeling for the Most Credible WCD and Maximum WCD scenarios indicates a 5 to 40 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 1 and a 5 to 10 percent probability of an unmitigated spill reaching the Guyana shoreline in Region 2. Deterministic oil spill modeling predicts that an unmitigated oil spill would remain offshore of Guyana for the Most Credible WCD scenario and for the Maximum WCD (Jun–Nov) scenario. Deterministic modeling predicts impact across the majority of the Region 1 shoreline for the (Dec–May) Maximum WCD scenario. Modeling mitigation under this scenario predicts a reduction in the predicted length of shoreline impact in Region 1, but the predicted length still represents the majority of the Region 1 shoreline. The deterministic modeling analysis does not predict shoreline impacts in Guyana outside of Region 1 for either the Most Credible WCD or Maximum WCD scenarios, regardless of season or the effects of mitigation. Potential transboundary impacts are discussed in Section 9.24, Transboundary Impacts.

As discussed in Section 8.9.3, Impact Assessment—Ecosystem Services, indigenous populations in the more remote coastal areas of Regions 1 and 2 make use of a range of coastal resources for subsistence and livelihoods. Communities that are directly adjacent to the coast include Three Brothers, Almond Beach, and Father's Beach. Indigenous villages located 5 to 10 kilometers (approximately 3 to 6 miles) inland from the coast in Regions 1 and 2 include Santa Rosa, Waramuri, Manawarin, Assakata, Imbotero, Smith's Creek, and Wakapau. These communities engage in a number of natural resource-based activities including small-scale agriculture (coconuts in particular), fishing, crabbing, hunting, trapping, heart of palm harvesting, and natural-medicine harvesting on the coast. Most of the indigenous communities from Region 1, and a few communities from Region 2 that are located inland from the coast, venture to the Shell Beach coastline (within the SBPA) to engage in these activities (ERM/EMC 2018). The communities depend on the waterways for potable and domestic water supply and, in most cases, the waterways are the only form of transportation available. Additionally, some of the indigenous villages within Region 1 have experienced an influx of migrants from neighboring Venezuela (both prior to and during the global COVID-19 pandemic). Communities are allowing these migrants to use the natural resources present within their communities for sustenance.

In the SBPA, fishing and crabbing are common activities at the westernmost end of Shell Beach (at the mouth of the Waini River) and easternmost end of Shell Beach (at the mouth of the Moruca River). An area along Shell Beach referred to as "Iron Punt," which can be accessed from the ocean and from Luri Creek, is also a common fishing and crabbing area. Aside from serving as a transit route, Luri Creek also provides communities with opportunities for fishing, crabbing, and bird hunting, particularly in the dry season, some hunting (labba, deer, land

turtles, ducks) in the wet season, and tourism-related sport fishing. In Region 2, shoreline areas provide for fishing and crabbing, coastal agriculture (including subsistence farming and cash crops), and hunting/trapping of iguanas and other species.

Indigenous communities in remote areas of Region 1, and to a much lesser extent in Region 2, rely on the coastal habitats for subsistence and livelihoods and have fewer alternative food sources and livelihood opportunities. In the unlikely event of an oil spill reaching the coast, provisioning resources used by indigenous communities could potentially be adversely impacted. In the event that mangrove forests and swamps along the coast are impacted by oil, species such as fish, crabs, birds, and wild animals (iguanas, deer, wild hog, agouti, labba, etc.), which are depended upon by indigenous communities as a source of protein, would potentially be impacted.

For these reasons, the intensity of an unmitigated marine oil spill on coastal indigenous communities is considered to be potentially **High**. The geographic extent of an unmitigated marine oil spill would include portions of the **Indirect AOI**. In the absence of mitigation, the impacts could persist over a multi-week basis, so the frequency is considered to be **Continuous**. Depending on the size of the spill, the effects, assuming no mitigation of the spill, would have the potential to extend beyond a year, so duration is conservatively considered to be **Long-term**. Applying the methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, these characteristics lead to a magnitude rating of **Large**. Consistent with the sensitivity ratings assigned for potential impacts on employment and livelihoods, a sensitivity rating of **High** is assigned assuming that the receptors are vulnerable populations and cannot adapt to the change without difficulty and cannot easily transition to alternate livelihood activities.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the pre-mitigation risk to Indigenous Peoples from this unplanned event is considered **Moderate** (Table 9.23-1).

The Project will establish an OSRP that will be implemented in the unlikely event of a spill. Effective implementation of the OSRP would reduce this risk by reducing the probability of oil reaching near-coastal waters or the Guyana coast. Additionally, a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established to further reduce this risk by compensating affected individuals (including Indigenous Peoples, if affected) for effects to livelihood as a result of an oil spill. Accordingly, the intensity of a mitigated marine oil spill on coastal indigenous communities is reduced to **Medium**.

The geographic extent of a mitigated marine oil spill would still include portions of the **Indirect AOI**, although the area affected would be substantially reduced with mitigation. On the basis that the impacts from a mitigated marine oil spill could persist over a multi-week basis, the frequency is considered to be **Continuous**. The effects, assuming mitigation of the spill, would be reduced to more than a week but less than a year, so duration is considered to be **Medium-term**. Applying the methodology described in Chapter 4, these characteristics lead to a magnitude rating of **Medium**. Consistent with the sensitivity ratings assigned for potential impacts on employment and livelihoods, the sensitivity rating is reduced to **Medium**, as the receptor may be able to adapt to the change or shift to alternate livelihood activities as a result of the livelihood assistance.

Applying the methodology in Chapter 4, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 9.1.1.9, Summary of Spill Scenarios Considered, a marine oil spill is considered **Unlikely**, so the residual risk of a (mitigated) marine oil spill to coastal indigenous communities (see Table 9.23-1) is considered **Minor**.

Table 9.23-1: Risk Rating for Potential Unplanned Event Impacts on Indigenous Peoples

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Indigenous Peoples	Unlikely	High	Moderate	Implement OSRP Implement claims and/or livelihood remediation processes for affected individuals	Minor

9.24. TRANSBOUNDARY IMPACTS

The planned Project activities are not predicted to have any measurable “transboundary impacts” (i.e., impacts outside the Guyana EEZ). All predicted impacts from planned Project activities will occur within the Guyana EEZ. However, there is the potential for transboundary impacts to result from unplanned events that may occur, such as oil spills. As the oil spill modeling indicates, transboundary impacts could potentially occur under Scenario 13 (2,500 bbl (400 m^3) offloading spill), Scenario 14 (88,728 BPD (14,196 m^3) release from a loss-of-well-control event over 30 days), and Scenario 15 (177,157 BPD (28,345 m^3) release from a loss-of-well-control event over 30 days) as defined in Section 9.1.1.9, Summary of Spill Scenarios Considered. These WCD rates represent the estimated maximum daily flow of oil from a loss-of-well-control scenario, and are used to understand the scope of the response that would be necessary in the event that such a release occurred. These types of releases are very rare; worldwide, there have been nine offshore loss-of-well-control incidents (with the oldest dating back to 1969) that discharged 100,000 bbl (16,000 m^3) or more to the environment (BSEE 2016). The unmitigated deterministic modeling results for Scenario 13 predict that the potential for coastal oiling would be limited to northern Trinidad and Tobago. Deterministic

modeling for Scenarios 14 and 15 indicate there is the potential for oil to reach portions of Trinidad and Tobago, Venezuela, Aruba, Bonaire, Curaçao, Barbados, St. Lucia, Grenada, St. Vincent and the Grenadines, the Dominican Republic, Haiti, and Jamaica. The mitigation that was applied to these WCD events was not scaled up for the higher discharge rates so that the performance could be compared among the releases. In the event that a higher-volume event occurred, additional resources would be applied to the response.

Modeling of an unmitigated spill predicts that surface oil would travel towards the northwest in all scenarios during both the Jun–Nov and Dec–May seasons. Differences in seasonal wind speed and direction result in a range of shoreline length predicted to be oiled. Stronger easterly winds would result in the potential for more significant shoreline oiling, particularly in Venezuela and Trinidad and Tobago, while lower wind speeds would allow the surface plume to be transported to the north of Trinidad and Tobago and into a portion of the Caribbean Sea.

Impacts on resources and receptors in these other countries would be similar to those discussed in this chapter for Guyana. Although the likelihood of a marine oil spill remains **Unlikely**, there would be the potential to impact the same resources and receptors discussed in the chapter for Guyana. Further, some additional resources could potentially be affected (e.g., corals), which recent marine surveys have documented as sparsely distributed across the middle and outer continental shelf and continental slope (ERM 2018a and ERM 2018b). The coastal sensitivity mapping conducted for the transboundary area potentially affected by a spill, as described in Section 9.1.6, Coastal Sensitivity Mapping, included the coastal regions of the countries that could potentially be impacted by unmitigated marine oil spills associated with FPSO offloading activities and/or loss-of-well-control events. A general overview of potential impacts on these countries is provided below.

9.24.1. Potential Impacts from an Offloading Spill (Scenario 13)

The impacts of an FPSO offloading spill (Scenario 13) are discussed separately from the loss-of-well-control events (Scenarios 14 and 15) because deterministic oil spill modeling predicts that an unmitigated offloading spill would have the potential to oil the shoreline of only one country outside of Guyana: Trinidad and Tobago. The probability of oil reaching Trinidad and Tobago's shoreline would be remote, approximately 5 to 10 percent (Figures 9.1-3a and 9.1-4a). If oil did reach the coast, the extent of impacts would vary seasonally. A 2,500 BPD (400 m^3) spill in the Jun–Nov season would have the potential to contact only the northern end of Trinidad (Figure 9.1-5a). Impacts from the same unmitigated spill in the Dec–May season could contact the southeast coast of Tobago, but would not come ashore in Trinidad (Figure 9.1-6a). A mitigated offloading spill would not be expected to reach the coast of any country in any season (Figures 9.1-7a, 9.1-7b, 9.1-8a, and 9.1-8b).

The coastal sensitivity mapping indicates that Trinidad and Tobago has several marine resources that could be potentially impacted by an offloading spill. Most of Tobago's coral reefs are on the west side of the island and would therefore be sheltered from oil carried westward from an offloading spill, but a few are located on the southern end of the island and could be exposed to oiling in the unlikely event that oil reached the island. Several other smaller reefs and seagrass meadows that fringe Tobago's southeast coast would also be exposed to oiling. There are also at least nine known marine turtle nesting beaches on Tobago's southeast coast that would be exposed to potential oiling from an offloading spill.

Four species of marine turtles (hawksbill [*Eretmochelys imbricata*], leatherback [*Dermochelys coriacea*], green [*Chelonia mydas*], and olive ridley [*Lepidochelys olivacea*]) nest on Trinidad, and all of these except olive ridley nest on Tobago as well. Portions of both islands' nesting beaches would be exposed to oiling by an unmitigated spill approaching from the east; slightly more than half of Tobago's nesting beaches are located on the west coast and would be protected from an offloading spill in any season. Nearly all of Trinidad's nesting beaches are located along the northern and eastern coasts and would be at risk of oiling if an unmitigated spill reached Trinidad. This risk would be greater in the Jun–Nov season in Trinidad and in the Dec–May season in Tobago. The most sensitive coastal species to an oil spill reaching Trinidad and Tobago is probably the American manatee (*Trichechus manatus*). Its known habitat in the country is exclusively located on the east coast of Trinidad in an area that would have a slight chance (5 to 10 percent probability) of being oiled from an offloading spill. Trinidad's seagrass communities are mostly located along the northwest coast near Chaguaramas and should be sheltered from an offloading spill, but one large seagrass meadow off Galera Point at the extreme northern end of the island could be exposed to oiling from an offloading spill, especially in the Jun–Nov season.

9.24.2. Potential Impacts from a Loss-of-Well-Control Event (Scenarios 14 and 15)

An unmitigated loss-of-well-control event could impact three main geographic regions:

- Trinidad and Tobago, the northern South American coast, and the so called "ABC Islands" (Aruba, Bonaire, and Curaçao);
- The southern Lesser Antilles (i.e., Grenada, St. Vincent and the Grenadines, St. Lucia, Martinique, and Barbados); and
- The southwestern Greater Antilles (i.e., Dominican Republic, Haiti, and Jamaica).

In the most general terms, oil spill modeling indicates that during winter months (Dec–May) a slick from an unmitigated oil spill from a loss-of-well-control event would take a west-northwesterly route through the Gulf of Paria and the southern and eastern coasts of Trinidad and Tobago. This scenario would expose the northern coast of South America and the southern Lesser Antilles to the bulk of the exposure to oiling. An equivalent slick from the same spill during the summer months (Jun–Nov) would track slightly more to the north, away from the western Venezuelan Coast and further north in the western Atlantic toward the central and southern portions of the Lesser Antilles, across the Caribbean Sea, and eventually to the

Greater Antilles. This seasonal difference in slick trajectories is the main reason that Barbados is only predicted to be affected by summertime spills (Table 9.24-1).

Modeling the most credible of the loss-of-well-control scenarios (i.e., the Most Credible WCD) indicates a risk of an unmitigated oil spill making landfall on several of the Lesser Antilles north of Tobago in either season. In the Greater Antilles, the Most Credible WCD in winter would be predicted to stay south of Jamaica, but the weaker trade winds in this season would allow the slick to reach the southern Dominican Republic. The influence of stronger trade winds in winter is predicted to create a narrower slick that tracks further south across the Caribbean Sea, avoiding the Dominican Republic but reaching Jamaica. For the larger loss-of-well-control event (i.e., Maximum WCD), the shift northward in the Jun–Nov season and additional volume associated with this scenario would allow the slick to contact Haiti and the Dominican Republic, while a wintertime slick would stay well south of the summertime route and only affect eastern Venezuela and southern Trinidad. Table 9.24-1 summarizes the differences in predicted risk of oil landfall from unmitigated spill scenarios according to scenario and season. The table also indicates whether there is a predicted risk of oil landfall for each season under a mitigated scenario, on the basis the release has been stopped within a period of 5.5 days, assuming no debris removal, and with the application of spill response measures.

Table 9.24-1: Predicted Risk of Oil Landfall by Unmitigated and Mitigated Loss-of-Well-Control Scenario and Season

Country	Most Credible WCD 88,728 BPD (14,196 m^3)				Maximum WCD 177,157 BPD (28,345 m^3)			
	Jun–Nov		Dec–May		Jun–Nov		Dec–May	
	Unmitigated	Mitigated	Unmitigated	Mitigated	Unmitigated	Mitigated	Unmitigated	Mitigated
Venezuela	X		X		X		X	X
Aruba	X		X		X		X	
Curaçao	X		X		X		X	
Bonaire	X		X		X		X	
Trinidad and Tobago	X		X		X	X	X	
Grenada	X		X		X		X	
St. Vincent and the Grenadines	X		X		X		X	
St. Lucia	X		X		X		X	
Martinique	X		X		X		X	
Barbados	X				X			
Dominican Republic			X		X			
Haiti					X			
Jamaica	X							

Note: Table includes results from stochastic and deterministic modeling analyses.

The following sections describe the specific coastal sensitivities in each of the countries that could be affected by a loss-of-well-control event and are organized according to the three main regions described above.

9.24.2.1. Trinidad and Tobago and the Northern South American Coast, including Aruba, Bonaire, and Curaçao

Potential Impacts on Trinidad and Tobago

Owing to its unique location at the southern end of the Lesser Antilles and relatively close proximity to the PDA, Trinidad and Tobago would have the highest potential to be affected by the transboundary impacts of any unmitigated loss-of-well-control event, regardless of season (see Figures 9.1-22a). The probability of oiling at least a portion of the coast of Trinidad and Tobago and/or its coastal waters is approximately 10 to 100 percent for the unmitigated Most Credible WCD scenario scenarios. The lower end of this probability range increases slightly for a loss-of-well-control event in the last half of the year, yielding a 20 to 100 percent probability of shoreline oiling under the Maximum WCD scenario. The highest probabilities of oiling occur on exposed, eastern-facing shorelines under both scenarios. A mitigated loss-of-well-control event would be expected to reach northern Trinidad and southern Tobago, but only for the Maximum WCD scenario and only in the Jun–Nov season (Figure 9.1-22b).

Sensitive coastal resources in this area include all of Trinidad's eastern and southern mangroves, manatee habitat, marine turtle nesting beaches, and forest reserves from Redhead in the north to Guayaguayare in the south. In Tobago, it includes numerous marine turtle nesting beaches and coral reefs, as well as several large seagrass meadows in the south near the Mount Pleasant area. The northern and southern coasts also have a high probability of shoreline oiling from approximately Toco to Mount Pleasant in the north and from Guayaguayare Bay to Islote Bay in the south, but the probabilities of oiling increase rapidly in an easterly direction along both coasts. The time of predicted arrival at shoreline ranges from 5 to 10 days for an unmitigated loss-of-well-control event.

Compared to the east coasts of Trinidad and Tobago, deterministic modeling predicts the western coast will be sheltered from oiling under both of the unmitigated scenarios in both seasons (see Figures 9.1-22a), posing a lower-level risk to Tobago's remaining marine turtle nesting beaches and its largest coral reef, Buccoo Reef, located adjacent to the southwest tip of the island.

Three marine IBAs (e.g., seabird breeding colonies and surrounding foraging areas, non-breeding concentrations, feeding areas for pelagic species) of global or regional importance to seabirds have been designated offshore Trinidad and Tobago. Two of these, Little Tobago Island and St. Giles Islands, are located near the northeastern tip of Tobago and would be exposed to oiling by a slick approaching from the southeast. Impact on these IBAs could include direct oiling of birds leading to illness or death, reduced reproductive success for the nine species of seabirds that are known to nest within at least one of the sites (Audubon's Shearwater [*Puffinus lherminieri*], Red-billed Tropicbird [*Phaethon aethereus*], Magnificent Frigatebird [*Fregata magnificens*], Brown Noddy [*Anous stolidus*], Brown Booby [*Sula*

leucogaster], Red-footed Booby [*Sula sula*], Bridled Tern [*Onychoprion anaethetus*], Sooty Tern [*Onychoprion fuscatus*], and Laughing Gull [*Leucophaeus atricilla*]), and/or loss of foraging opportunities for any of the nesting species or for roosting Masked Boobies [*Sula dactylatra*], which are found on the St. Giles Islands. The third marine IBA, West Coast Mudflats, is located on the west-central coast of Trinidad and would be sheltered from the effects of an oil spill originating at the Project.

Numerous fishing areas are located east of Trinidad and could be impacted by a large unmitigated subsea release of crude oil. The largest and most concentrated coastal/nearshore fishing activities in this part of Trinidad's EEZ are located along the southeastern coast from Cocos Bay in the north to Guayaguayare Bay in the south. These areas extend from the coast to approximately 20 kilometers (12 miles) offshore. Further north in the vicinity of Salybia, Sena, and Saline Bays, fishing is concentrated slightly further offshore, approximately 15 to 30 kilometers (9 to 18 miles) from the coast. All of these areas would have a high probability of being impacted by a large unmitigated subsea release of crude oil from a loss-of-well-control event.

According to the Food and Agricultural Organization of the United Nations (FAO 2018), the artisanal fleet (which operates within a few kilometers of the coast) accounts for the bulk of fishery sector's production in Trinidad and Tobago (71 to 77 percent of total landings and about 60 percent in terms of value), and the artisanal fleet tends to supply most of the domestic demand for fish in Trinidad and Tobago. The industrial fleet is smaller and tends to focus on higher value species (e.g., tuna, flying fish) that are directed to export markets. Consequently, the socioeconomic impacts of fisheries impacts would differ depending on the type of fishery that would be impacted by a particular spill. Spills that remain offshore and only affect the industrial fleet would have a greater proportional impact on high-value fisheries and on the export markets, while spills that reach inshore areas would impact both the inshore and offshore fleets and would impact exports as well as domestic fish supplies.

Potential Impacts on Venezuela

Stochastic modeling indicates that the Venezuelan coast could be oiled by both unmitigated WCD events during any time of year, but that the probability of oil reaching a specific location on the coast is highly dependent on season and size of the event (Figures 9.1-23a and 9.1-23b). With the exception of the Gulf of Venezuela, which would be protected from oil approaching from the east by the Paraguaná Peninsula, stochastic modeling indicates a 5 to 90 percent probability of surface oil reaching the Venezuelan coastal zone. Probabilities of shoreline oiling in specific locations depend on scenario and season. The highest probabilities of shoreline oiling would be in eastern Venezuela from December through May. Stochastic modeling predicted a less than 20 percent probability of oil reaching any part of Venezuelan shoreline from an unmitigated Most Credible or Maximum WCD occurring from June through November; however, an unmitigated Most Credible or Maximum WCD event from December through May would have a greater than 80 percent chance of oil reaching some portion of Venezuelan shoreline.

Deterministic modeling generally indicates a lower risk to Venezuela than stochastic modeling. Deterministic modeling suggests that only the Maximum WCD scenarios pose oiling risks to mainland Venezuelan shores, particularly those located in the Orinoco Delta (see Figures 9.1-23a and 9.1-23b). Additionally, deterministic models predict that risks of shoreline oiling from the Most Credible WCD event would be limited to Venezuela's offshore islands. The island of Blanquilla would be at risk of shoreline oiling from a Most Credible WCD event occurring from December through May, and the islands Los Roques and Blanquilla would be at risk from the same scenario occurring if it occurred from June through November. A mitigated loss-of-well-control event would be expected to reach eastern Venezuela, but only for the Maximum WCD scenario and only in the Dec–May season.

Together the stochastic and deterministic modeling analysis of an unmitigated loss-of-well-control event identified three main areas of the Venezuelan coast as being at risk of oiling:

- The Orinoco Delta
- The Gulf of Paria and the Paria Peninsula
- Los Roques and other offshore islands

Table 9.24-2: Shoreline Oiling Stochastic Probabilities of Shoreline Oiling in Venezuela for an Unmitigated Loss-of-Well-Control Event

Location	Most Credible WCD		Maximum WCD	
	Summer	Winter	Summer	Winter
Orinoco Delta	5–30%	5–80%	5–30%	5–90%
Gulf of Paria and Paria Peninsula	5–20%	5–80%	5–20%	5–80%
Los Roques	20–30%	30–40%	10–30%	30–40%
Isla la Blanquilla	40–50%	40–50%	40–50%	50–60%

Note: Table excludes areas where probability of shoreline oiling is lower than 5 percent

These areas support several categories of sensitive coastal resource including marine turtle nesting beaches, manatee habitat, seagrass meadows, mangroves, and coral reefs.

The Orinoco River Delta is located south of Trinidad in eastern Venezuela and is the most important coastal area that could be affected by a loss-of-well-control event from a biodiversity perspective. The Orinoco River Delta supports numerous biological resources of regional and global significance, including extensive mangroves, diverse shorebird and estuarine fish communities, threatened and endangered marine turtles and marine mammals, and artisanal and commercial fisheries (Miloslavich et al. 2011). Modeling indicates that the shortest time of arrival in the delta for an unmitigated Most Credible spill would be about 10 to 25 days in summer and approximately 5 to 10 days during winter, although oil could take longer to reach some areas within the delta. The western portion of the Orinoco Delta, particularly the more exposed outer shorelines of the hundreds of small islands scattered through the delta, constitute one of two primary concentrations of marine turtle nesting activity in the country (the other being the Paria Peninsula, as discussed below).

The Gulf of Paria and the Paria Peninsula contains the second largest concentration of marine turtle nesting beaches in Venezuela, most of which are located west of Rio Caribe on the northern and extreme eastern coasts. Mangroves are also widespread on the northern and southern coasts of the peninsula, and the northeastern portion of the peninsula is mapped as an important bird nesting area. The peninsula has an approximately 5 to 80 percent probability of being oiled under an unmitigated loss-of-well-control scenario, depending on season (Table 9.24-2).

The only offshore islands at risk in an unmitigated WCD event include Isla La Blanquilla and Los Roques Archipelago. The most well-known of these islands is the Los Roques Archipelago. Los Roques was designated as a national park by the Venezuelan government in 1972 and contains a network of coral reefs, seabird colonies, seagrass meadows, and at least one marine turtle-nesting beach. Located approximately 210 kilometers (130.5 miles) north of Caracas, the park encompasses over 220,000 hectares (543,632 acres), is the largest marine park in the Caribbean, and is an internationally known tourist destination. Venezuela's marine IBAs are mostly centered on offshore islets, many of which are remote, uninhabited, and difficult to access due to hazardous cliffs and fringing limestone and coral reefs.

Isla la Blanquilla is also predicted to be exposed in the unlikely event of an unmitigated loss-of-well-control event. Most of Venezuela's coral reefs are also located around the offshore islands. The probability of oiling from an unmitigated spill varies widely for the offshore islands, and for Isla la Blanquilla ranges from approximately 40 to 60 percent depending on location, spill volume, and time of year (Table 9.24-2).

Seagrass is one of the most ubiquitous coastal marine habitats in Venezuela and is widespread in these areas. Seagrass can be found in numerous locations from just southeast of Caracas east along the mainland coast to the Orinoco Delta, including much of the Paria Peninsula and several of the offshore islands. Essentially the entire portion of this area west of Rio Caribe would have a low risk of oiling regardless of the time of year, so approximately half of Venezuela's known seagrass meadows would not be at significant risk of being exposed by a loss-of-well-control event.

Potential Impacts on Bonaire

Stochastic modeling indicates Bonaire would have a 10 to 20 percent chance of being oiled under the Most Credible WCD scenario in both seasons and under the Maximum WCD scenario from December through May, and a 10 to 40 percent chance of shoreline oiling under the Maximum WCD scenario from June through November. Stochastic modeling also predicts the earliest arrival of oil to shorelines between 25 and 40 days. Deterministic modeling indicates that only an unmitigated Most Credible WCD occurring from June through November would result in oiling of the north, east, and south coasts of Bonaire, and that no shoreline oiling would occur as a result of the Most Credible WCD from December through May (Figures 9.1-26a and 9.1-26b). No mitigated loss-of-well-control events would be expected to have the potential of oiling the Bonaire coast, regardless of scenario or season.

Bonaire is a rocky, arid island surrounded mostly by fringing coral reefs. The most prominent environmental feature of the island is the Bonaire Marine Park, which includes all of the waters around Bonaire and Klein Bonaire to a depth of 60 meters (197 feet) from the high water mark. The eastern-facing portion of the park and its coral reef communities and would potentially be exposed to oiling from unmitigated loss-of-well-control events. Dive-oriented ecotourism is a substantial driver of the local economy; however, most commercial dive sites are located on the west side of the island, which would be mostly protected from oiling under all loss-of-well-control scenarios.

Potential Impacts on Curaçao

Stochastic modeling indicates a probability of oil coming ashore in Curaçao year-round under both WCD scenarios ranging from 10 to 40 percent, with the earliest arrival of oil to shorelines between 25 and 40 days. Deterministic modeling indicates Curaçao's coasts would be only be at risk of oiling in an unmitigated Most Credible loss-of-well-control scenario during the Jun–Nov season (see Figures 9.1-27a and 9.1-27b). In this scenario, the southeastern coasts would be most impacted, but some oil would come ashore in the north and west coastal areas as well. No mitigated loss-of-well-control events would be expected to have the potential of oiling the Curaçao coast, regardless of scenario or season.

The most prominent environmental feature that would be at risk is the Christoffel / Shete Boka Park, which protects approximately 6 kilometers of rocky coastline in the northeastern portion of the island. No significant corals, mangroves, or other coastal sensitivities exist in the area that could be at risk of oiling, although marine turtle nesting activity has been reported in small so called "pocket beaches" in the park. The Curaçao Underwater Park stretches approximately 20 kilometers (12 miles) along the southeastern coast from Willemstad to the southern end of the island and is Curaçao's only Marine Protected Area (MPA). It reportedly supports 65 species of coral, more than 350 species of fish, mangroves, and seagrass. Modeling indicates the park could be at risk in the event of an unmitigated WCD event.

Potential Impacts on Aruba

Stochastic modeling indicates a low probability, ranging from 5 to 20 percent, of oil coming ashore in Aruba year-round under both WCD scenarios. Deterministic modeling indicates no risk of coastal oiling in Aruba under either the Most Credible or Worst Case WCD Scenarios (see Figures 9.1-28a and 9.1-28b). No mitigated loss-of-well-control events would be expected to have the potential of oiling the Aruba coast, regardless of scenario or season.

The most prominent environmental feature that would be at risk is Arikok National Park, which encompasses approximately 7 kilometers (4.4 miles) of rocky coastline in the south-central portion of the island. No significant corals, mangroves, or other coastal sensitivities exist in the area that could be at risk of oiling, although limited marine turtle nesting activity has been reported in Arikok National Park. There are several kilometers of mangrove-lined coastline on the south-central portion of the west coast and a coastal bird sanctuary on the northwest coast, but these would be naturally protected from oiling in all modeled scenarios.

9.24.2.2. Southern Lesser Antilles (excluding Trinidad and Tobago)

Stochastic modeling indicates four Lesser Antillean countries north of Tobago would be at risk of oil coming ashore from an unmitigated loss-of-well-control event from both the Most Credible and Worst Case WCD Scenarios in both the Jun–Nov and Dec–May seasons, including Grenada, St. Vincent and the Grenadines, St. Lucia, and Martinique. Barbados, which is located approximately 170 kilometers (105.6 miles) east of the main Antillean Archipelago, would only be at risk of shoreline oiling during the Jun–Nov season for either the Most Credible or Worst Case WCD Scenarios. Probability of shoreline oiling in the Lesser Antilles is generally highest in the south and decreases in a northerly direction. Table 9.24-3 summarizes the stochastic probabilities of shoreline oiling for each of the Lesser Antillean countries that could be affected by shoreline oiling under either scenarios or season.

Table 9.24-3: Predicted Risk of Oil Landfall by Unmitigated and Mitigated Loss-of-Well-Control Scenario and Season

Country	Most Credible WCD 88,728 BPD (14,196 m^3)		Worst Case WCD 177,157 BPD (28,345 m^3)	
	Jun–Nov	Dec-May	Jun–Nov	Dec-May
Grenada	5-60%	30-40%	5-60%	20-40%
St. Vincent and the Grenadines	30-40%	10-30%	10-50%	10-40%
St. Lucia	5-20%	5-10%	5-10%	5-10%
Martinique	5-10%	5-10%	5-10%	5-10%
Barbados	5-10%	—	5-10%	—

Note: Table excludes areas where probability of shoreline oiling is lower than 5 percent

Stochastic modeling indicates shoreline arrival of oil in the Lesser Antilles occurring anywhere from 5 to 35 days; oil would generally take a few days more to reach the more northern islands then the southern islands. Deterministic modeling predicts fewer countries in the Lesser Antilles could be affected by shoreline oiling than stochastic modeling. Deterministic modeling suggests that the only islands north of Tobago that would be affected by either loss-of-well-control scenario would be St. Vincent and the Grenadines and Grenada. No mitigated loss-of-well-control events would be expected to have the potential of oiling any of the Lesser Antilles north of Tobago, regardless of scenario or season (see Figures 9.1-24a, 9.1-24b, 9.1-25a, and 9.1-25b).

Potential Impacts on St. Vincent and the Grenadines

The most significant coastal sensitivities on St. Vincent proper are seagrass meadows, which have been mapped along much of the island's east coast. St. Vincent also has coral reefs along its west coast, but these would be protected from oiling regardless of seasonality. The numerous smaller islands to the south of the main island of St. Vincent (i.e., the Grenadines) have much more extensive coral reefs, many of which are exposed to the east and would therefore be at risk of oiling. The Tobago Cays Marine Park, located near Mayreau Island near the southern end of the Grenadines, contains several such easterly facing reefs and would be mostly exposed to oil drifting from the east (see Figures 9.1-25a and 9.1-25b).

Potential Impacts on Grenada

Like St. Vincent, Grenada also has extensive seagrass meadows adjacent to much of its east coast and portions of its west coast; but unlike St. Vincent, Grenada has significant coral growth as well. These seagrass meadows and reefs are located not only adjacent to the main island but also several of the smaller offshore cays, including Ronde Island and the South Carricou Islands. Because most of the seagrass and coral habitats are located along the east coast, they would be exposed to oiling, but some important habitats that would be protected from oiling events exist along the west coast. These include a large seagrass meadow near Saint Georges and two smaller coral reefs in Grand Anse Bay near the southwestern end of the island. Grenada does not have large mangrove areas, but there are several small mangroves on the south coast and several small mangroves on the west coast near Hillsborough. The outer portions of the southern mangroves would probably experience minor oiling from a loss-of-well-control event that reached Grenada; but owing to their nearly due-south exposure, their inner portions would likely be sheltered from the worst impacts of such an event. The western mangroves near Hillsborough would be protected from oiling regardless of seasonality.

Grenada has four MPAs: Woburn / Clarks Court Bay MPA, Molinière-Beauséjour MPA, Sandy Isle/Oyster Bed MPA, and Grand Anse MPA. Woburn/Clarks Court Bay MPA is located on the southern tip of the island and includes Hog Island and Calivigny Island (Finlay 2012). The southern-most portions of the MPA—especially the eastern portion of Calivigny Island—would probably experience minor oiling from a loss-of-well-control event that reached Grenada, but the northern portions of the MPA would likely be protected from oiling by Calivigny Island and Point Egmont to the southeast. Molinière-Beauséjour MPA is located in the south-central portion of the west coast (GMAFF 2010). Sandy Isle/Oyster Bed MPA is located adjacent to the southwest shoreline of Carricou Island (MOCPM undated). Grand Anse MPA is located on the southwestern tip of the island (CBF 2021). Molinière-Beauséjour, Sandy Isle/Oyster Bed, and Grand Anse MPAs would all likely be protected from oiling in the event a spill reaches Grenada.

Potential Impacts on St. Lucia

Similar to the other islands listed in this section, St. Lucia has extensive seagrass meadows mapped along its east coast. It also has a few small, scattered reef areas along the east coast, although these are mainly confined to two areas: south of Vierge Point in the south and between Chaloupe Bay and Grand Anse Beach in the north. All of these areas would be exposed to some degree to oiling from a loss-of-well-control event. The most extensive marine protected area on the east coast is the East Coast Marine Management Areas, which encompass the area from Pigeon Island in the north to Dennery in the south. It contains all or part of six marine reserves, most of which are of importance for the protection of mangroves and turtle nesting beaches.

Potential Impacts on Martinique

Martinique has limited amounts of sensitive marine and coastal habitats, such as mangroves, reefs, and seagrass. Most of these communities are found in the southern portion of the island. On the east coast, mangroves are found almost exclusively south of Presqu'lle de al Caravelle.

The most extensive mangroves in the country are located in Fort de France Bay on the west coast, and would be protected from the effects of oil approaching from the east. Coral reefs occur mainly as small patch reefs located a short distance offshore, and are found along the east coast from approximately Basse Pointe in the north to the southern tip of the island, although most are concentrated between Presqu'lle de al Caravelle and Le Francois in the south. Seagrass is patchily distributed, primarily along the east coast. Most of the sensitive habitats on the east coast would be exposed to oil approaching from the southwest, although two reef areas along the northeast coast between Basse Pointe and Le Marigot would be afforded a degree of protection by Presqu'lle de al Caravelle.

Potential Impacts on Barbados

Barbados has a number of fringing reefs along its western coast, but its most extensive reef formations are on its north and south coasts. The northern and western reefs would be protected from oil approaching from the southeast, but the southern reef would be at risk of oiling. Seagrass is not extensive in Barbados, but sparse seagrass beds exist between the fringing reefs and shore on the southeast coast, approximately between Crane Beach and Fortescue. Virtually all of these communities would be at risk of oiling if oil from a loss-of-well-control event were to reach Barbados. Leatherback turtles nest between February and July in these same areas. Hawksbills also nest in Barbados but they generally nest along the south and west coasts, where they would be at least partially protected from oil approaching the coast from the PDA.

9.24.2.3. Greater Antilles

Potential Impacts on the Dominican Republic

Deterministic modeling predicts that only the southwestern coast of the Dominican Republic would be at risk of oiling during an unmitigated Maximum WCD spill during the Jun–Nov season (Figure 9.1-29b) and in an unmitigated Most Credible WCD occurring Dec–May (Figure 9.1-29a). The nearshore marine zone along this entire area is contained in the Arrecifes de Suroeste (Southwest Reefs) Marine Sanctuary and Scientific Reserve, which is an array of coral reefs and seagrass meadows located along the coast. The preserve was established to conserve natural habitats between La Espanola Island and the Jaragua National Park and encompasses South Yaque River estuary and wetlands. This area is purported to support the American manatee, dolphins, and marine mammals (CaMPAM undated). Jaragua National Park occupies much of the land and nearshore marine territory in this area. The park has cultural significance due its numerous caverns that contain pictograms and petroglyphs from the Taino culture, as well as other pre-Columbian archaeological sites. The park is reported to support 130 bird species (10 of them are endemic), solenodons and hutias, as well as American manatees and bottlenose dolphins (UNESCO undated).

In addition to the resources described above, the Dominican Republic has six marine and coastal protected areas: Banco de la Plata y de la Navidad and Estero Hondo marine mammal sanctuaries, Montecristi and La Caleta marine parks, and Jaragua and Parque del Este National

Parks. Banco de la Plata y de la Navidad supports several species of marine mammals and is best known for the large number of humpback whales that frequent the area, although it also contains the wrecks of multiple 16th century Spanish galleons. Estero Hondo is part of the Montecristi marine park complex. Esteron Hondo is primarily known for supporting the largest population of manatees in the Dominican Republic, although it also supports bottlenose dolphins. The larger Montecristi marine park supports mangrove forest, extensive coastal wetlands, dry forest, and the largest expanse of coral reefs in the Dominican Republic, with 24 species of coral and 45 species of fishes (Girot 2019). Banco de la Plata y de la Navidad and Montecristi/Estero Hondo are located off the northeast and northwest coasts of the Dominican Republic, respectively, and would likely be somewhat sheltered from a spill approaching from the southeast by neighboring Puerto Rico.

La Caleta, Jaragua, and Parque del Este are located on the Dominican Republic's southern coast. La Caleta is known primarily for its abundant fish life and as a reef-diving and wreck-diving tourism center (Wielgus et al. 2010). Jaragua National Park supports dolphins and manatees, contains the most pristine coral reefs on Hispaniola Island, and includes sea turtle nesting beaches (UNESCO 2018). Parque del Este is known as a diving and snorkeling destination, for its white sand beaches, and for archaeological significance to the Taino culture. La Caleta, Jaragua, and Parque del Este would all be exposed to potential impacts from oil approaching from the south, but Parque del Este is located at the southeastern tip of the Dominican Republic and would likely have the greatest exposure of any of the country's protected areas.

No mitigated loss-of-well-control events would be expected to have the potential of oiling the Dominican Republic's coast, regardless of scenario or season.

Potential Impacts on Haiti

Deterministic modeling predicts that Haiti would be exposed to potential shoreline oiling from an unmitigated Maximum WCD scenario during the Jun–Nov season (see Figure 9.1-30b). The greatest risk of oil reaching Haiti would be along the southern shore of the Tiburon Peninsula, from the border with the Dominican Republic in the east to approximately Les Cayes in the west. This section of coast is dominated by series of sandy beaches interspersed with rocky shoreline. Mangroves occur, but are sparse. This area also includes Île-à-Vache, an offshore island that was designated a Marine Protected Area by the Haitian government in 2016 as part of the larger La Hotte Biosphere Reserve (UNESCO 2021).

No mitigated loss-of-well-control events would be expected to have the potential of oiling the Haitian coast, regardless of scenario or season.

Potential Impacts on Jamaica

Deterministic modeling indicates that Jamaica's southern coast would be at risk of oiling during an unmitigated Most Credible WCD scenario during the Jun–Nov season (see Figures 9.1-31a). The most significant environmentally sensitive area within this zone is the Portland Bight Protected Area (PBPA), which is the largest protected area in Jamaica. Its terrestrial area is

520 square kilometers (201 square miles) in the southern sections of St. Catherine and Clarendon parishes, including the coastline from east of Hellshire to almost Milk River in the west. It includes contiguous coastal land and the marine area out to the 200-meter (656-foot) depth contour. Sections of the PBPA were officially designated as a Ramsar site in 2006. Sandy beaches and cays are also part of the biodiversity of the PBPA. The coast is a combination of sandy beaches (several of which support nesting marine turtles and nesting seabirds), nearshore islands that support endemic lizards, and mangroves. Benthic marine resources in the PBPA include seagrass and coral reefs (C-CAM 2013). The Black River Lower Morass is another Ramsar site located approximately 15 kilometers (9.3 miles) west of the PBPA and Jamaica's largest wetland. It supports the IUCN-listed American crocodile (Vulnerable). It is listed as an IBA by BirdLife International.

Outside of the PBPA, there are several significant reefs along Jamaica's southern coast. Three reef areas exist between the PBPA and the Black River Morass. Two other reef areas exist at the Pallisidoes, a series of sand banks south of Kingston. Another prominent reef system exists between Morant Bay and Morant Point on the southeast corner of the island.

No mitigated loss-of-well-control events would be expected to have the potential of oiling the Jamaican coast, regardless of scenario or season.

9.24.3. Impacts of International Importance

In addition to the country-specific impacts listed above, seabirds would have the potential to be affected at a regional scale. Since 2010, BirdLife International has focused its efforts on identifying Marine IBAs with specific significance to seabirds. The types of sites that qualify as Marine IBAs include seabird breeding colonies, foraging areas around breeding colonies, non-breeding (usually coastal) concentrations, migratory bottlenecks, and feeding areas for pelagic species (BirdLife International 2019). No Marine IBAs have been identified in Guyana, but there are 49 Marine IBAs of global or regional importance to seabirds that lie within the swept zone of the unmitigated Maximum WCD scenario (considering both seasons together). These sites contain regionally or globally important breeding and foraging sites for numerous species of seabirds, including species with elevated conservation status (i.e., IUCN listing status of Vulnerable or higher). Two of these 49 Marine IBAs that are located along the southern coastline of Hispaniola (Haiti and the Dominican Republic) are particularly significant as they support the world's only known breeding sites for Black-capped Petrel (*Pterodroma hasitata*) (IUCN Endangered).

During the seabird breeding period, the timing of which shifts from year to year based on the availability of food resources, many of the 49 Marine IBA sites within the swept zone of an unmitigated loss-of-well-control spill support hundreds to thousands of breeding seabirds. If a marine oil spill occurs during the seabird-breeding period and oil reaches a breeding colony or impacts individuals offshore that then introduce oil to the colony, the impacts on seabird populations could be significant. Seabirds typically nest close together on islands or shorelines and forage at higher density in proximity to their nesting sites, making large numbers of birds and their eggs susceptible to oiling. Some seabirds lay only one egg at a time, so they have an

already low reproductive rate, which makes these species more susceptible to adverse impacts from oil spills that occur in the breeding season (because they could lose an entire recruitment year) (NOAA 2015).

9.24.4. Mitigation of Transboundary Impacts

The unmitigated oil spill modeling used to characterize potential transboundary impacts did not take into consideration any emergency response actions. Implementation of the OSRP would help to significantly reduce potential transboundary impacts just as it would reduce impacts within the Guyana EEZ, as demonstrated by oil spill modeling that considers OSRP implementation (i.e., mitigated scenarios). In particular, EEPGL has established a response plan that will enable deployment of a capping stack on well locations within 5.5 days, assuming no debris removal. The 5-day period is a deployment-ready time estimate for installation of the capping stack, which includes logistics mobilization (aircraft, deployment vessel), stack configuration and testing, load-out, and transit times. Therefore, modeling for a mitigated scenario is based on a 5.5-day installation of the capping stack at the well for the WCD scenarios, and that timing is reflected in the mitigated scenarios modeling. Mitigated scenario modeling (see Section 9.1.5, Oil Spill Modeling Results) demonstrates that this in combination with other response measures (e.g., dispersant application) would significantly reduce the extent of transboundary impacts. In any case, EEPGL will work with representatives of the respective countries that could be potentially impacted by a large oil spill to be prepared for the unlikely event of a spill by:

- Coordinating operations and communications between different command posts;
- Creating a transboundary workgroup to manage waste from a product release, including identifying waste-handling locations in the impacted regions and managing commercial and legal issues (wastes collected in countries outside of Guyana will be handled according to the regulations required specific to that location);
- Identifying places of refuge in the impacted region where response vessels could go for repairs and assistance;
- Determining how EEPGL and the impacted regional stakeholders can work together to allow equipment and personnel to assist in a spill response outside the region while still retaining a core level of response readiness within the jurisdictions;
- Determining financial liability and establishing claims and/or livelihood remediation processes during a response to a transboundary event; and
- Working with local communities within the impacted areas to raise awareness of oil spill planning and preparations.

With respect to working with representatives of the respective countries, the communication protocol for country-to-country engagement is through the Ministry of Foreign Affairs at the direction of the Government of Guyana.

10. CUMULATIVE IMPACT ASSESSMENT

10.1. INTRODUCTION

The Project Development Area (PDA) is located approximately 203 kilometers (approximately 126 miles) northeast of the coastline of Georgetown, so there are a limited number of opportunities for the Project to cumulatively impact resources that would be impacted by other activities. These other activities include other offshore EEPGL oil and gas activities (e.g., Liza Phase 1 Project development, Liza Phase 2 Development, Payara Development Project, and ongoing exploration drilling); potential future offshore Guyana oil and gas exploration by other developers; and other non-oil and gas projects. These Project and non-Project activities together could cumulatively impact some resources such as the following:

- Climate via emissions of greenhouse gases (GHGs);
- Marine water quality via discharge of drill cuttings that could increase total suspended solids (TSS) concentrations in the water column;
- Special status marine fish species (via changes in distribution due to altered water quality) and special status seabird species (via attraction to offshore facilities or disturbance from Project facilities);
- Marine mammals via vessel strikes or potential disturbance from underwater sound;
- Marine turtles via vessel strikes;
- Marine fish via impacted water quality;
- Riverine mammals via vessel strikes and displacement;
- Marine use and transportation via additional marine congestion, especially near Georgetown Harbour;
- Employment and livelihood via interference with artisanal fishing activities;
- Community health and wellbeing via increased demand on limited medical treatment capacity;
- Social infrastructure and services via increased demand for limited housing and lodging; and
- Waste management infrastructure capacity via increased burden on waste management facilities in Georgetown.

This section discusses a cumulative impact assessment (CIA) conducted to evaluate the potential contribution of the Project toward the cumulative impacts on resources—identified herein as Valued Environmental Components (VECs).

The approach taken for the CIA follows the International Finance Corporation's (IFC's) *Good Practice Handbook—Cumulative Impact Assessment and Management: Guidance for Private Sector in Emerging Markets* ("the Handbook") (IFC 2013). The Handbook provides a methodology for identifying significant cumulative impacts; the methodology includes a desktop review of publicly available information and consultation with key stakeholders. This methodology focuses on environmental and social components referred to in the handbook as VECs, which are: (1) rated as "critical" by potential Project-Affected Communities (PACs)[1] and/or the scientific community; and (2) cumulatively impacted by the Project under evaluation, by other projects, and/or by natural environmental and social external drivers (IFC 2013).

10.2. OBJECTIVES AND SCOPE

The overall objective of this CIA is to identify and assess the contribution by the Project to cumulative impacts. It is based on information included throughout other sections of this EIA, information generated for the Liza Phase 1, Liza Phase 2, and Payara Development Project EIAs, information from prior and ongoing studies commissioned by EEPGL, information provided by EEPGL, and information available in the public domain. The specific objectives of the CIA are:

- Identify VECs that could be impacted cumulatively in the onshore and offshore areas potentially affected by the Project, considering input from stakeholders and potential PACs through the consultation process;
- Identify other existing and planned projects and environmental and social external drivers that could cumulatively impact VECs;
- Undertake a high-level assessment of potential cumulative impacts on VECs, considering the Project and the other identified existing and planned projects and external drivers in the area; and
- Recommend a management framework for the integrated management of potential cumulative impacts.

[1] PACs are defined as local communities potentially directly affected by the Project (consistent with IFC Performance Standard 1, paragraph 1 [IFC 2012]).

10.3. METHODOLOGY

10.3.1. Definitions of Key Terminology for the Cumulative Impact Assessment

The following are definitions of key terminology used in the CIA.

Cumulative Impact: Impacts that result from the successive, incremental, and/or combined effects of an action, project, or activity added to other existing, planned, and/or reasonably anticipated actions, projects, or activities. For practical reasons, the identification, assessment, and management of cumulative impacts includes those effects generally recognized as important on the basis of scientific concern and/or concerns of PACs.

CIA: Process used to identify and evaluate cumulative impacts.

Other Projects: Existing, planned, or reasonably expected future developments, projects, and/or activities potentially affecting VECs.

External Drivers: Sources or conditions—other than those captured in the Other Projects category—that could affect or cause physical, biological, or social stress on VECs, such as natural environmental and social stressors, broad-ranging human activities, and other external stressors. These can include climate change, population influx, or deforestation, among others. These are typically less defined and planned than Other Projects.

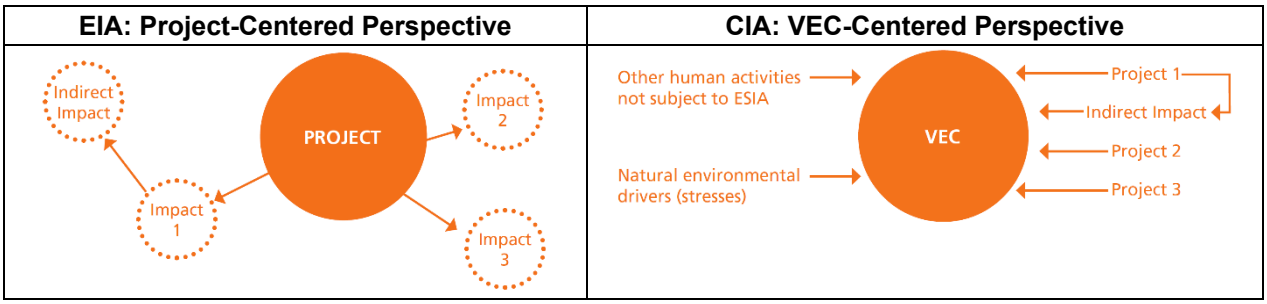
VECs: Environmental and socioeconomic components considered as important by the scientific community and/or PACs. VECs may include:

- Physical features (e.g., water quality)
- Biological features (e.g., habitats, wildlife populations);
- Ecosystem services (e.g., protection from natural hazards, provision of food);
- Natural processes (e.g., water and nutrient cycles, climatic conditions);
- Socioeconomic conditions (e.g., community health, economic conditions); and
- Cultural heritage or cultural resources aspects (e.g., archaeological, historic, traditional sites).

VECs reflect the public and scientific community's "concern" or special interest about environmental, social, cultural, economic, or aesthetic values (IFC 2013). According to the IFC's methodology, VECs are considered the ultimate recipients of cumulative impacts because they tend to be at the ends of impact pathways.

10.3.2. Overall Cumulative Impact Assessment Approach

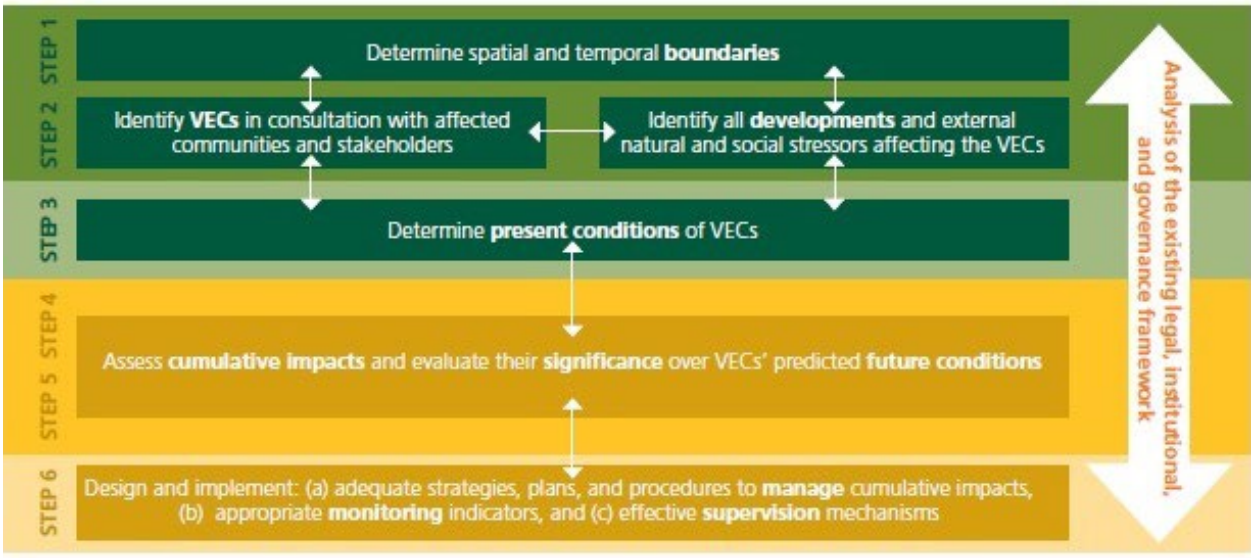
Unlike an EIA, which focuses on a project as a generator of impacts on various environmental and social resources/receptors, a CIA focuses on VECs as the receptors of impacts from different projects and activities (see Figure 10.3-1). In a CIA, the potential overall resulting condition of the VEC and its related viability are assessed.



Source: IFC 2013

Figure 10.3-1: Comparing EIA and CIA

As previously described, the CIA is based on information available in the public domain, information obtained during the EIA process for the Liza Phase 1, Liza Phase 2, and Payara Development Project EIAs, information from other studies commissioned by EEPGL, and information provided by EEPGL. The assessment follows the six steps for a CIA (see Figure 10.3-2). The process is iterative and flexible, allowing for some steps to be revisited in response to the results of others. For example, the VEC selection step may need to be adjusted after the potential impacts of the Project are identified. The steps are described in detail below.



Source: IFC 2013

Figure 10.3-2: Summary of IFC's Cumulative Impact Assessment Methodology

10.3.3. Limitations

The Handbook takes into consideration the limitations that a private developer may face when carrying out a CIA; the Guyana Environmental Protection Act requires preparers of EIAs to identify limitations on availability of information to support the EIA, or difficulties encountered in compiling such information.

The limitations applicable to this CIA, include: (1) incomplete information about Other Projects and activities (e.g., the information is not available in the public domain); (2) uncertainty with respect to the implementation of future Other Projects; and (3) difficulty in establishing thresholds or limits of acceptable change for VECs, and therefore the associated priority rating for potential cumulative impacts.

10.3.4. Determination of Spatial and Temporal Boundaries

The geographic scope of the EIA was defined as the Project's Indirect Area of Influence (AOI) (see Chapter 5, Scope of the Environmental Impact Assessment). Based on an assessment of the VECs for the CIA, it was determined that the Indirect AOI is sufficient to serve as the spatial boundary of the CIA, in that it covers: (1) the extent of the selected VECs, and (2) the spatial and temporal extent of the potential impacts from the Project, Other Projects, and external drivers. Figure 10.3-3 shows the spatial boundary of the CIA.

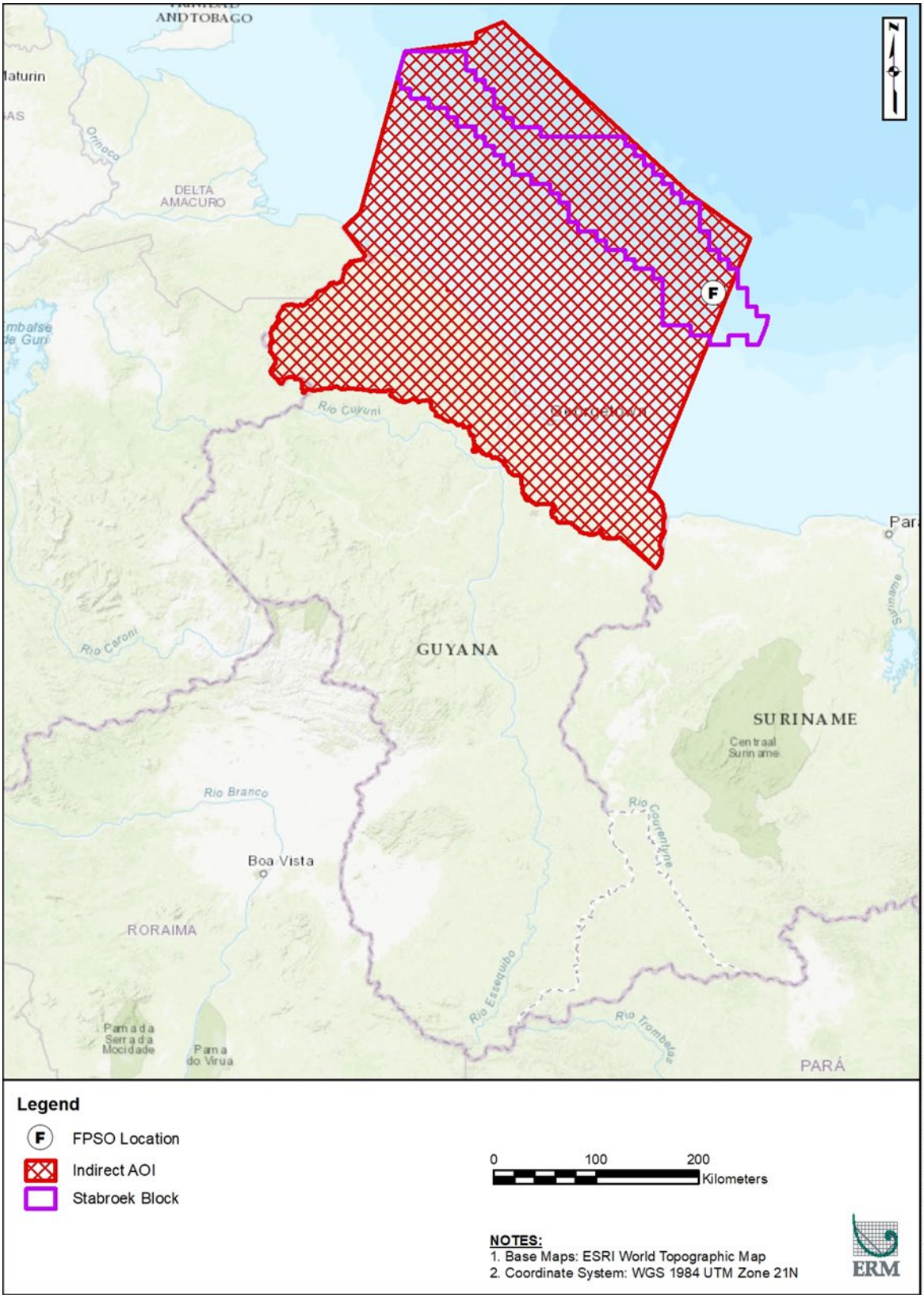


Figure 10.3-3: Spatial Boundary of the Cumulative Impact Assessment

Temporal limits for a CIA are inherently uncertain due to the limited information typically available regarding potential future projects. For this reason, good international oilfield practice suggests using a 3-year temporal boundary when conducting a CIA (IFC 2013). While the CIA uses this time horizon for non-EEPGL projects, the temporal boundary used with respect to the Project and other potentially planned EEPGL projects is through 2044. This temporal boundary is based on the greater level of certainty for other potentially planned EEPGL projects (see Figure 10.3-4). As discussed further in Section 10.4.1, Other EEPGL Projects, the other existing, planned, and potentially planned EEPGL projects considered in the CIA include the following:

- Continued exploration drilling;
- Liza Phase 1 Development Project;
- Liza Phase 2 Development Project;
- Payara Development Project;
- A future development project that is referred to herein as “FPSO Development Project #5” (FPSO #5);
- A future development project that is referred to herein as “FPSO Development Project #6”; (FPSO #6)
- The Guyana Fiber Optic Enablement Project, which involves installation of a fiber optic cable from the Stabroek Block to onshore cable landing sites (“the FOC Project”);
- The Guyana Office Complex (GOC) Project, which includes the construction of office buildings and ancillary structures near Ogle Airport to serve as the head office for EEPGL; and
- A project to transport associated gas from the Liza Phase 1 PDA to shore for creation of natural gas liquids (NGLs) and for power production at a third-party power plant, referred to as the Gas to Energy or “GTE Project.”

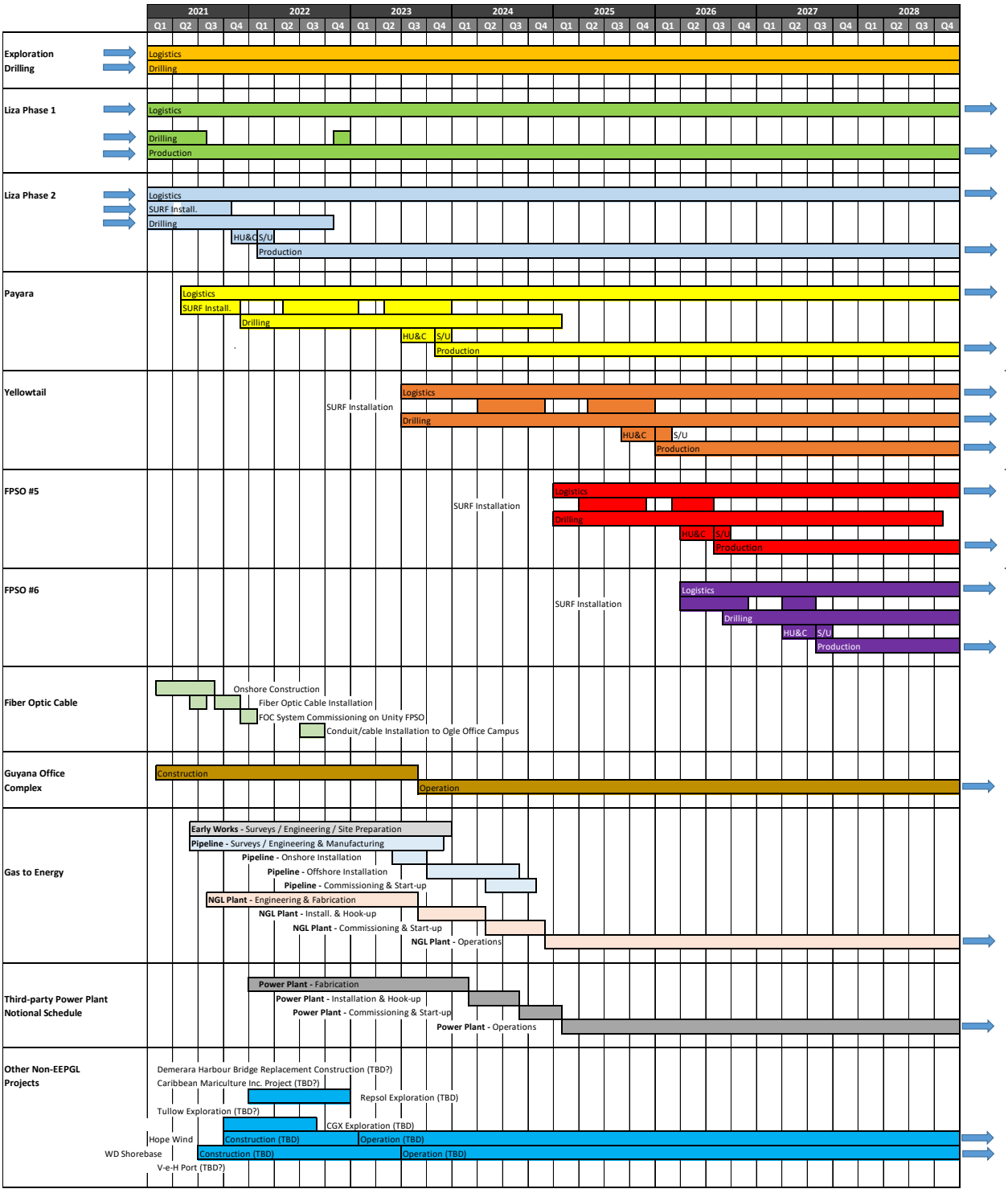


Figure 10.3-4: Temporal Boundary of the CIA for EEPGL's Projected Offshore Activities and other Non-EEPGL Projects (Conceptual for CIA Purposes)

The Project's drilling and installation stages are expected to initiate in 2023 and extend as late as 2032[2] and the production operations stage is expected to start in 2025 and last at least 20 years (2025 to at least 2044). Other non-EEPGL projects identified as reasonably foreseeable future developments in the vicinity of the Project include: the Harbour Bridge Replacement Project in Georgetown; a mariculture project referred to as Caribbean Mariculture, Inc. (CMI)[3]; oil and gas exploration including (1) Repsol exploration activities in the Kanuku Block; (2) Tullow exploration activities in the Orunduik Block; and (3) CGX exploration activities in the Correntyne and Demerara Blocks; the Hope Windfarm Project; the West Demerara Shorebase; and the Vreed-en-Hoop Port Facility. With the expanding oil and gas industry in Guyana, the potential for additional support facility (e.g., shorebase) development could overlap with the timeline of the Yellowtail Project. However, the Consultants did not identify any such projects (beyond the West Demerara Shorebase and Vreed-en-Hoop Port Facility listed above) with sufficient detail or certainty to warrant their inclusion in the CIA.

The estimated timelines for EEPGL projects and future exploration activities, as well as for non-EEPGL projects, are represented conceptually on Figure 10.3-4 for the purposes of the CIA. These timelines are preliminary in nature.

10.3.5. Identification of Valued Environmental Components, Other Projects, and External Drivers

10.3.5.1. Valued Environmental Components

Since 2017 and through the time of developing this EIA, EEPGL and its Consultants have held hundreds of stakeholder engagement events in coastal Regions 1, 2, 3, 5, and 6, and more than 1,000 engagement events and individual stakeholder meetings in Region 4. These include key informant interviews, EIA public scoping consultation and disclosure meetings, coastal mapping efforts, fisherfolk engagements, oil spill response awareness and training events, community outreach events (e.g., informational booths, school fairs, job fairs), and capacity-building efforts. As part of these engagement efforts, the Consultants have made targeted efforts to reach vulnerable groups, including indigenous communities in the coastal areas of Region 1. The Consultants have taken specific care during public engagements to take the opinions of women, the elderly, and youth into consideration, including at public meetings and in focus groups (for detailed information on Project-specific engagement see Section 4.7, Stakeholder Engagement).

Throughout the engagement program, engagements with key stakeholders have included local and national government agencies, non-governmental organizations, academia, local

[2] The Yellowtail drilling campaign could commence as early as the second quarter of 2022 for the purposes of accelerated subsurface data collection and optimal use of the Stabroek drill ship time. The potential scope for 2022 drilling could include top-hole sections of up to five wells, but likely no completions in the reservoir interval(s). In this case, wells would be temporarily plugged and re-entered for completion operations during the primary drilling campaign for the Yellowtail project. For the purpose of this EIA, it is assumed that drilling for the Project could extend as late as 2032 depending on the total number of wells drilled.

[3] The Consultants were not able to identify any recent information indicating that the CMI project is still planned for implementation. As a conservative measure, however, it was assumed for the purpose of the CIA that the project is still planned.

communities, civil society, and local industries. Information collected during these engagements provided the Consultants with information that was used to develop a list of preliminary VECs and assess the value or importance of these preliminary VECs to stakeholders.

Scoping Consultations

In addition to these engagements, EEPGL held a number of virtual scoping consultation meetings for the Yellowtail Project, which interested parties from any location could attend. Table 10.3-1 lists the scoping consultation meetings conducted specifically for the Yellowtail Development Project; information from these meetings was considered in the selection of VECs.

Table 10.3-1: Scoping Consultation Meetings (2021)

Date	Region	Location	Number of Participants
May 27	All Regions	Virtual (Zoom meeting)—afternoon session	42 participants
		Virtual (Zoom meeting)—evening session	Not available
May 28	Region 6	No. 66 Village—Fishing Cooperative	35 participants
May 31	Region 1	Mabaruma—Mabaruma Primary School	46 participants
June 2	All Region	Virtual (Zoom meeting)—morning session	25 participants
		Virtual (Zoom meeting)—evening session	36 participants
June 4	Region 4	Georgetown—Umana Yama	15 participants

EIA Development

A number of stakeholder meetings, discussions, and information exchanges have occurred during the development of the EIA. This engagement has involved local communities, including NDCs and Village Councils in Region 1, and other stakeholder groups. Topics of discussion have included land use, agriculture, cultural heritage, private sector development, tourism developments, energy projects, or new infrastructure. For stakeholders with relevant information, further questions were asked about mitigation, monitoring, and safeguarding of any related impacts on valued components as a result of those other anticipated projects and activities.

Ecosystem Services Study

In addition to these meetings, in 2017/2018, a total of 64 focus group engagements were conducted for validation of data collected as part of the Liza Phase 1 post-permit ecosystem services study (ERM/EMC 2018). The following stakeholders participated in these meetings:

- Coastal Neighborhood Democratic Councils, Town Councils, and Village Councils in Regions 1 through 6;
- National Toshaos Council representatives; and
- Coastal Amerindian communities in and around the Shell Beach Protected Area in Region 1.

During these engagements, a screening exercise was employed, involving a series of questions about VECs, as detailed below:

- What are the environmental, social, or cultural attributes or components in this area (of the Project) that you value most? These may include:
  - Rivers/bodies of water
  - Air quality
  - Acoustic environment
  - Infrastructure
  - Forest cover
  - Wild species of plants
  - Biodiversity and animals
  - Landscape
  - Land use
  - Economic activities (e.g., tourism)
  - Fisheries and agriculture
  - Livelihoods
  - Cultural values
- Why are these valuable?
- What is the current condition of the component?
- What do you think is an acceptable condition of the component?
- Is this component currently affected by some human activity or natural factor?

This helped to understand and establish the value of the component to beneficiaries and scope-in those components that would be further evaluated as part of the cumulative assessment. The prioritization of VECs used the same approach as the ecosystem services evaluation and focused on identifying components that were important to local stakeholders, that would be difficult to replace, and whose loss or degradation could adversely affect stakeholders. The prioritization process considered the component's importance to beneficiaries (including intensity of use, scope of use, degree of dependence, and general importance expressed by stakeholders) as well as the availability, accessibility, cost, and sustainability of spatial alternatives (including both natural replacements and anthropogenic substitutes). A priority rating was given to the components. Any that were rated medium, high, and critical were included in the VEC selection process under "confirmed to be valued by an identifiable stakeholder group," as detailed in Section 10.5.1, Selected Valued Environmental Components for Inclusion in the Cumulative Impact Assessment.

In May 2019, the above-referenced stakeholder groups were revisited to perform a validation exercise, whereby stakeholders provided input on the data previously recorded and provided updates on the function and value of each ecosystem service in their community, based on recent activities (see Appendix S, Enhanced Coastal Sensitivity Mapping—Ecosystem Services Final Reports). Community-level engagement in 2021 also gathered updates about ecosystem services, including priority resources, trends, and changes in use or availability of resources as a result of the COVID-19 pandemic, heavy rainfall and flooding, and other recent events.

10.3.5.2. Other Projects

Through a review of publicly available information and interviews with EEPGL, government authorities, and proponents of other potential planned projects, the Consultants identified existing and potential future planned projects located within the spatial and temporal boundaries of the CIA having the potential to result in cumulative impacts on identified VECs (see Section 10.4.1, Other EEPGL Projects, and Section 10.4.2, Other Non-EEPGL Projects).

10.3.5.3. External Drivers

Regionally relevant external drivers were identified by the Consultants in the course of developing the other components of the EIA and based on publicly available information (see Section 10.4.3, External Drivers).

10.3.6. Description of Valued Environmental Component Conditions

The existing conditions of the selected VECs were characterized based on the data presented in the environmental and social existing conditions sections of the EIA (Chapters 6 to 8). The VEC baselines provide information on the VECs' current conditions and helped to inform the assessment of anticipated resilience against potential cumulative impacts.

10.3.7. Assessment of Cumulative Impacts on Valued Environmental Components

CIAs are future-oriented, and project contributions are assessed as the difference between the expected future condition of the VEC and the condition that could result in the future in the context of external drivers, Other Projects, and the Project under evaluation. To this end, this step of the CIA assesses the future conditions of the VECs, considering the Project, Other Projects, and external drivers. The cumulative impacts are then given a priority level, based not in terms of the amount of change, but in terms of the potential resulting impact to the vulnerability and/or risk to the sustainability of the VEC. If the residual impact significance for a VEC was rated as **Minor** or higher for at least one potential impact associated with planned Project activities (refer to Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources, for residual impact significance ratings) the VEC was identified as potentially eligible for the CIA. Additionally, if the residual risk rating for any VEC was rated as **Moderate** or higher for at least one unplanned event with a likelihood of at least **Possible** (refer to Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events, for residual risk ratings), the VEC was identified as potentially eligible for the CIA.

The results of the CIA are presented in tabular format in Section 10.6, Assessment of Cumulative Impacts on VECs, and each potential cumulative impact is prioritized based on the following definitions:

- **High Priority:** The VEC is expected to be adversely impacted by Other Projects and/or External Drivers and the future addition of the Project could incrementally contribute to the potential adverse impact and vulnerability of the VEC. Actions should be implemented in the short-term to mitigate potential adverse cumulative impacts on the VEC.
- **Medium Priority:** The VEC could potentially be impacted by Other Projects and/or External Drivers, and the Project could potentially incrementally contribute to the adverse impact and vulnerability of the VEC. Actions should be implemented in the medium-term to mitigate potential adverse cumulative impacts on the VEC.
- **Low Priority:** The VEC could potentially be impacted by Other Projects and/or External Drivers, but the Project would not be expected to contribute to the adverse impact or its contribution would be expected to be negligible. No additional actions are required to mitigate potential adverse cumulative impacts on the VEC; the mitigation measures and embedded controls of the Project itself are sufficient to manage the Project's contribution to potential cumulative impacts.

10.3.8. Cumulative Impact Management Framework

Internationally recognized good practices for managing cumulative impacts include:

- "Effective application of the mitigation hierarchy (avoid, reduce, and remedy) in the environmental and social management of the specific contributions of a project to expected cumulative impacts; and
- Undertaking best efforts to engage, leverage, and/or contribute in multi-stakeholder collaborative initiatives or discussion groups to implement management measures that are beyond the capacity and responsibility of any individual project developer." (IFC 2013)

The embedded controls and management measures included in the EIA provide a means to mitigate the specific contributions of the Project to effects on VECs, following the mitigation hierarchy (refer to mitigation measures in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources; management framework in Chapter 11, Environmental and Social Management Plan Framework; and a summary of embedded controls and mitigation measures in Chapter 13, Recommendations). Supplementing these controls and management measures, the CIA provides recommendations for EEGPL to apply in the context of the Project (and/or in its other projects) to manage potential cumulative impacts on these VECs.

10.4. Other Projects and External Drivers

Given the exploration success within the Stabroek Block to date and growing international interest, there is reasonable likelihood that oil and gas exploration and/or oil and gas-related development in Guyana will continue for the foreseeable future. For example, in addition to the

original Liza discovery, EEPGL has made several additional discoveries since 2016. There is also potential for oil and gas activities by other operators in the region. Other than for periodic vessel transit across the Stabroek Block, such operations would take place outside of the Stabroek Block. Therefore, the closest another operators' activities could be expected to approach the Project would be approximately 30 kilometers (approximately 19 miles), which is the shortest distance from the Yellowtail PDA to the boundary with a non-EEPGL license block)[4].

Fourteen other (non-Project) activities have been identified as relevant with respect to the potential for their impacts to interact with Project impacts on a given VEC. These are described below, organized as Other EEPGL projects (Section 10.4.1) and Other Non-EEPGL projects (Section 10.4.2). Section 10.5.3, Potential Impacts from Other Projects, summarizes the Other Projects' potential impacts.

10.4.1. Other EEPGL Projects

After consulting with EEPGL, the Consultants identified the following Other EEPGL Projects to be included in the CIA:

- Continued exploration drilling
- Liza Phase 1 Development Project
- Liza Phase 2 Development Project
- Payara Development Project
- FPSO #5 Development Project
- FPSO #6 Development Project
- FOC Project
- GOC Project
- GTE Project

Summaries of these projects are presented below. Figure 10.4-1 shows the current or future locations of the Liza Phase 1 Floating Production, Storage, and Offloading (FPSO) vessel, the Liza Phase 2 FPSO, the Payara FPSO, and (pending receipt of authorization) the Yellowtail FPSO. At this time the nominal areas in which FPSO #5 and FPSO #6 are assumed for the purpose of this assessment to be located in the eastern part of the Stabroek Block, near prior exploration wells with discoveries.

[4] Other operators could request permission from EEPGL to conduct geophysical or geotechnical survey operations within the Stabroek Block. However, for safety reasons, any such activities would not be allowed to overlap with EEPGL operations in space and time. Therefore, the potential impacts associated with such operations (e.g., marine discharges, traffic, sound) would not significantly contribute to cumulative impacts.

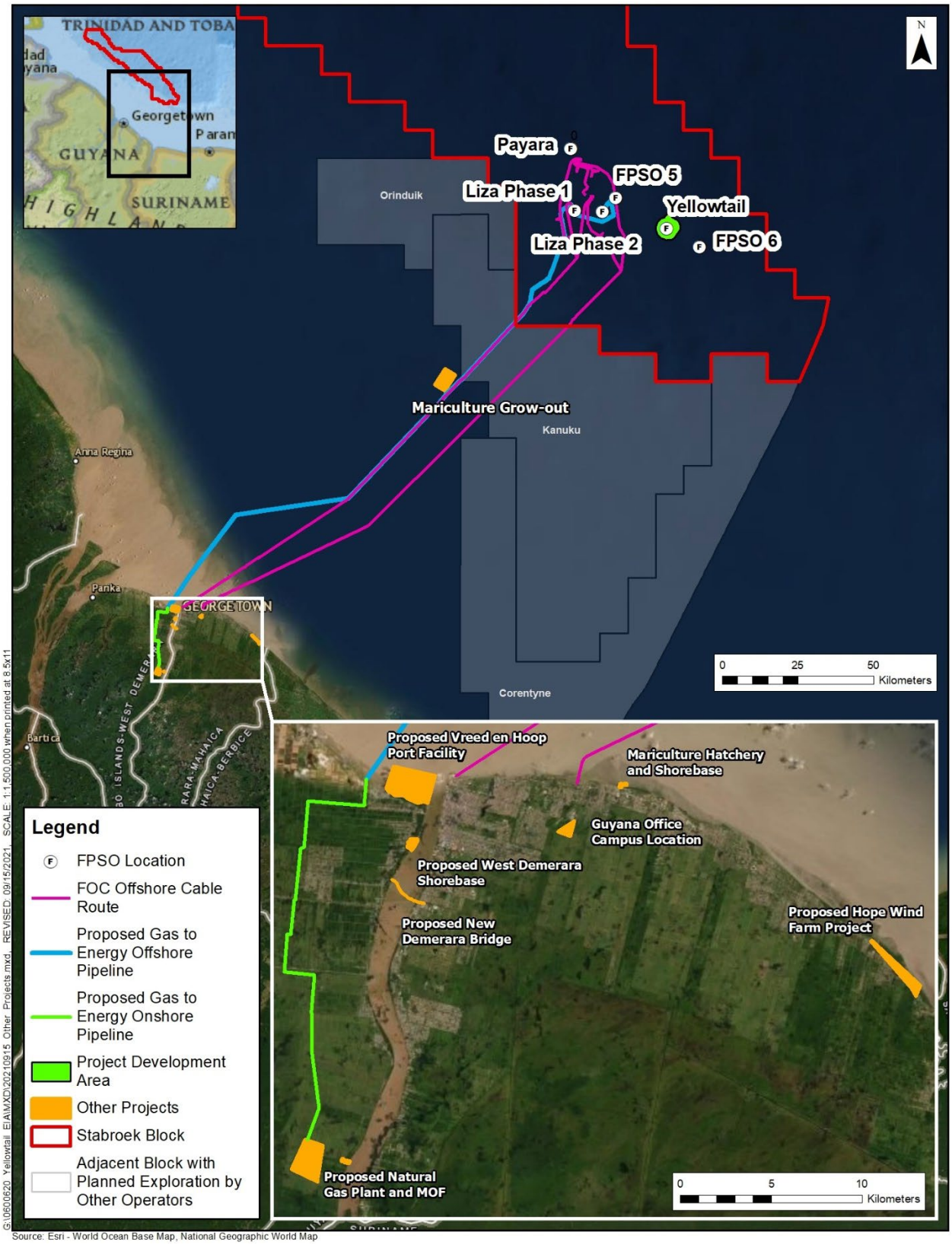


Figure 10.4-1: Conceptual Locations of Other Projects

Continued exploration drilling could occur throughout the Stabroek Block and into adjacent blocks. Continued exploration is not shown on the figure due to commercial sensitivities and lack of definition of exploration program outlook. The figure also shows the route of the offshore extent of the fiber optic cable for the FOC Project and the location of the GOC that is currently under construction. The figure shows the offshore pipeline for the GTE Project, which will originate from the Liza Phase 1 and Liza Phase 2 FPSOs and traverse approximately 220 kilometers (137 miles), connecting with an onshore pipeline at a shore landing located west of the Demerara River. The onshore pipeline will extend approximately 27 kilometers (17 miles) from the shore landing to the NGL Plant Site. The NGL Plant Site lies approximately 23 kilometers (14 miles) upriver on the west bank of the Demerara River on abandoned sugarcane fields.

10.4.1.1. Liza Phase 1, Liza Phase 2, and Payara Development Projects

Project Summary

The Liza Phase 1, Liza Phase 2, and Payara Development Projects have been permitted to develop their respective offshore resources by drilling approximately 17 subsea development wells (Liza Phase 1), up to 33 development wells (Liza Phase 2), and up to 45 development wells (Payara) in the eastern half of the Stabroek Block. Each of these projects will use an FPSO to process, store, and offload the recovered oil. Each FPSO will be connected to the wells via associated Subsea, Umbilicals, Risers, and Flowlines (SURF), which will transmit produced fluids (i.e., oil, gas, produced water) from production wells to the FPSO, as well as treated gas and water from the FPSO to injection wells. The Liza Phase 1 PDA, where the drilling and production operations activities will collectively occur, is a 76-square kilometer (km^2) (29-square miles [mi^2]) area located approximately 190 kilometers (approximately 120 miles) from the coastline. The Liza Phase 2 PDA is an approximately 80 km^2 (31 mi^2) area located approximately 183 kilometers (114 miles) from the coastline. The Payara PDA is an approximately 95 km^2 (37 mi^2) area located approximately 207 kilometers (128 miles) northeast from the coastline.

The Liza Phase 1, Phase 2, and Payara Development projects will each consist of four stages, some of which may overlap: (1) Drilling; (2) Installation, Commissioning, and Start-up; (3) Production Operations; and (4) Decommissioning. Shorebases, laydown areas, warehouses, fuel supply, and waste management facilities will support all three projects across project stages. These three projects will share logistics, including use of marine support vessels traversing between the Stabroek Block and shorebases in Guyana or Trinidad and Tobago, and helicopters traversing between the Stabroek Block and heliport facilities in Georgetown.

Project Schedules and Distances from the Yellowtail Development Project

The drilling, installation, commissioning and start-up stages of the Payara Development Project and the production operations stages of the Liza Phase 1, Liza Phase 2, and Payara projects are projected to overlap with the Yellowtail Project. The Liza Phase 1, Liza Phase 2, and Payara FPSOs will be located approximately 31 kilometers (19.2 miles), 22 kilometers (13.7 miles), and

41 kilometers (25 miles) from the proposed location of the Yellowtail FPSO, as shown on Figure 10.4-1.

10.4.1.2. Continued Exploration Drilling

Project Summary

Exploration drilling by EEPGL is ongoing as of the writing of this EIA and is planned to continue to take place in the Stabroek Block and in the adjacent Canje and Kaieteur blocks, over the next several years, subject to future authorizations and continued exploration success (i.e., discoveries).

Project Schedule and Distance from the Yellowtail Development Project

While continued exploratory drilling is contingent on the results of exploration, the current EEPGL exploration program is nominally envisioned to extend through 2028 (Figure 10.3-4). Previously authorized exploration drilling is currently ongoing in the Stabroek and Canje blocks and applications for environmental authorization for additional exploration drilling programs in the Canje and Kaieteur blocks have been submitted to the EPA and are under review as of the writing of this EIA.

10.4.1.3. FPSO #5 and FPSO #6 Development Projects

Project Summary

The FPSO #5 and FPSO #6 Development Projects are assumed for the purpose of this CIA to be designed, in concept, similar to the Yellowtail Development Project (i.e., an FPSO with a subsea tieback system). They are tentatively assumed to be located in the eastern half of the Stabroek Block near previous exploration discoveries (see Figure 10.4-1). Although the sizing and capacity of the FPSO #5 and FPSO #6 facilities are not currently defined, for the purposes of this CIA it is assumed that they will be roughly similar to the Yellowtail Development Project FPSO size/capacity, and development well count (including production, water injection, and gas re-injection wells). The locations and design details for the FPSO #5 and FPSO #6 developments are conceptual in nature and defined only for the purposes of the CIA.

Project Schedule and Distance from the Yellowtail Development Project

The estimated timeline for the FPSO #5 Development Project includes drilling and installation activities starting during 2025 (assuming an environmental authorization is issued) and continuing into 2028, with production operations starting in 2026 (Figure 10.3-4). The estimated timeline for the FPSO #6 Development Project includes drilling and installation activities starting during 2026 (assuming an environmental authorization is issued) and continuing through 2028, with production operations starting in 2027 (Figure 10.3-4). These estimated timelines for the FPSO #5 and FPSO #6 developments are projected only for purposes of the CIA.

For the purposes of this CIA, the projected distances from the Yellowtail FPSO to the FPSOs for the FPSO #5 and FPSO #6 Development Projects are 19.5 kilometers (approximately 12.1 miles) and 12.4 kilometers (approximately 7.7 miles), respectively.

10.4.1.4. Fiber Optic Cable Project

Project Summary

EEPGL has recently received approval for the Fiber Optic Cable Project (FOC Project), which will install fiber optic communication infrastructure from the Stabroek Block to shore, enabling high-speed, low-latency communications and data transfer between EEPGL's FPSOs and shore (see Figure 10.4-1). The network includes two landing sites with terrestrial transmission to a cable landing station and then to EEPGL's new GOC site. The approved FOC Project includes installation of subsea infrastructure, including optical distribution units (ODUs), located south of the Liza Phase 1 and Liza Phase 2 FPSOs, and connection of the Liza Phase 1, Liza Phase 2, and Payara FPSOs to the ODUs. As part of a future application for environmental authorization, EEPGL will propose to connect one of the ODUs to a Yellowtail drill center.

The cable will be installed using a variety of methods depending on the water depth and the on-site conditions. To protect the cable as much as possible through the fishing grounds, the cable will be plow-buried from approximately 32 kilometers (20 miles) from shore up to a water depth of 150 meters (492 feet); from this point seaward, seabed laying is sufficient and the cable will self-bury (i.e., the cable will be laid on the ocean floor and will bury itself through natural processes). For burial portions, the cable will be trenched to a depth of 1.5 meters (5 feet).

Project Schedule and Distance from the Yellowtail Development Project

Construction of the offshore cable, distribution system, and the onshore landing sites is ongoing as of the writing of this EIA, with planned commissioning of the project connection to the Liza Phase 2 FPSO in late 2021 / early 2022. Construction of the connection to the GOC is planned for later in 2022. As discussed above, the Yellowtail FPSO will be connected to one of the ODUs as part of a future application for environmental authorization.

10.4.1.5. Guyana Office Complex

Project Summary

EEPGL is constructing a new Guyana headquarters, referred to herein as the GOC. The campus will be constructed on a greenfield 16.1 hectare (15-acre) site and will comprise two buildings and associated infrastructure.

Project Schedule and Distance from Yellowtail Development Project

The proposed location for the GOC is near the Eugene F. Correia International (Ogle) Airport (see Figure 10.4-1). EEPGL leased the parcel of land from Ogle Airport Inc. to construct two office buildings, an outdoor pavilion, and parking areas. Construction is ongoing as of the writing of this EIA, with planned completion in late 2023.

10.4.1.6. Gas to Energy Project

Project Summary

EEPGL is currently seeking environmental authorization to construct and operate a pipeline that will transport natural gas from the Liza Phase 1 and Liza Phase 2 FPSOs to an onshore natural gas liquids processing plant (NGL Plant), from which dry gas will be supplied to a power plant. The power plant will be constructed, owned, and operated by the Government of Guyana or another entity.

The offshore pipeline will traverse approximately 220 kilometers (137 miles), connecting with the onshore pipeline at a shore landing located west of the Demerara River. The onshore pipeline will extend approximately 27 kilometers (17 miles) from the shore landing to the NGL Plant Site. The NGL Plant Site lies approximately 23 kilometers (14 miles) upriver on the west bank of the Demerara River on abandoned sugarcane fields.

Project Schedule and Distance from the Yellowtail Development Project

The preliminary schedule for the GTE Project calls for engineering and construction of the onshore pipeline, offshore pipeline, and NGL Plant during 2022 through 2024, with commissioning and start-up of these components in late 2024 / early 2025. Operations of the pipeline and power plant are expected to last at least 25 years. The GTE Project is approximately 22 kilometers (13.7 miles) from the Yellowtail FPSO at its closest point (i.e., the Liza Phase 2 FPSO connection point).

10.4.2. Other Non-EEPGL Projects

10.4.2.1. Replacement of Demerara Harbour Bridge

Project Summary

The Demerara Harbour Bridge in Georgetown has been in operation for approximately 40 years and is no longer able to efficiently service either present or estimated future traffic demands. The Government of Guyana has elected replacement of the heavily used bridge as a means of relieving congestion of both road- and river-based vessel traffic induced by the opening and closing of the retractor spans that allow large vessels to pass. In 2013, a pre-feasibility study identified three alternative locations for the new bridge: Houston, Peters Hall (the existing location), and New Hope. In August 2021, the Ministry of Public Infrastructure issued a project summary evaluating replacement of the bridge, calling for the replacement bridge to span the Demerara River from Nandy Park to La Grange, slightly upstream of the existing bridge (Figure 10.4-1), and for the existing bridge to be closed and demolished once the new bridge is in operation. The replacement structure will be a fixed four-lane bridge with a vertical clearance over the channel of approximately 50 meters (164 feet) above the maximum tide level. The proposed design connects to the main road network at the West Bank Public Road and the Mandela to Eccles Road (Ministry of Public Works 2021). The EPA has exempted the new

bridge project from having to do an EIA, requiring instead an Environmental and Social Assessment and Management Plan (EPA 2021).

Project Schedule and Distance from Yellowtail Development Project

The new bridge is proposed to be located slightly upstream of the existing bridge, close to one of the shorebases that EEPGL is planning to use to support the Yellowtail Development Project (Figure 10.4-1). The timeline for the bridge replacement was not identified in publicly available records, so it is assumed for the purpose of the CIA that construction-related activities for the bridge might occur at the same time as construction and/or operation of the Yellowtail Development Project.

10.4.2.2. Caribbean Mariculture Project

Project Summary

In December 2017, an updated project summary for a mariculture project by CMI was submitted to the EPA. The Consultants were not able to identify a more recent submittal in the public domain, so it is assumed for the purpose of the CIA that the project is still proposed and has not changed in design or location. According to the project summary document, the project is designed to farm the following marine fish species: southern red snapper (*Lutjanus purpureus*), Atlantic grouper (*Epinephelus itajara*), cobia (*Rachycentron canadum*), grey snapper (*Cynoscion acoupa*), and gillbacker (*Sciades parkeri*), which are currently caught by the marine capture fisheries in Guyana. The project asserts that by growing selected species of fish through aquaculture, the supply of fish will become more reliable and that it will reduce the pressure on wild fish stocks.

The project would have three main components: (1) hatchery, (2) shorebase area, and (3) growout area. The proposed hatchery location is at Le Ressouvenir, East Coast Demerara. The proposed shorebase operations would be land-based, at Le Ressouvenir, East Coast Demerara, located next to the hatchery, and bordered by mangroves to the east and west, the Atlantic Ocean to the north, and by residential areas and drainage structures to the south. The proposed growout operations would be located in the open ocean.

The summary document briefly describes the mariculture operation:

- **Hatchery:** Broodstock of the various species would be captured alive from the wild, and transported to the hatchery. This broodstock would be placed in eight concrete tanks, each with a capacity of 28 cubic meters (36.6 cubic yards). The broodstock would then be induced using environmental manipulation (i.e., photoperiod, temperature, water quality and nutrition), so as to facilitate spawning. Chlorine bleach would be used for cleaning the tanks and the hatchery in general. No additives would be used. In the hatchery, the broodstock would be spawned, producing eggs, which would then hatch into fry (very small fish). These fry would be grown to fingerlings (slightly larger fish). Lastly, the fingerlings would be transported to the growout area, where they would be stocked and grown to market-sized fish. While in the hatchery, the broodstock, fry, and fingerlings would be fed a high quality feed.

- **Shorebase:** This operation would service the hatchery and growout areas, providing storage areas, locations for the mooring of vessels, and other supporting facilities.
- **Growout area:** In the growout area, the project would use large mesh pens with a mesh size that would accommodate the size of fingerlings to be stocked from the hatchery operations, prevent the entry of predators, and facilitate adequate water exchange. Fingerlings will be grown to market size in these pens. Each pen will be 6,400 cubic meters (226,000 cubic feet) in size. The growout operation would be serviced by feeding, holding, and harvesting support infrastructure, as well as logistics support, so as to be able to get inputs onto, and products off of, the facility. The growout operation would also have accommodations for staff, who would be required to supervise operations and conduct required tasks on a 24-hour basis.

Project Schedule and Distance from the Yellowtail Development Project

The December 2017 project summary report indicated that construction would take approximately 3 years; however, a start date for the construction has not been published by CMI. According to the 2017 Project Summary, the project lifespan is expected to be 50 years. The Consultants were not able to identify any recent information indicating the CMI project is still planned for implementation. As a conservative measure, however, it was assumed for the purpose of the CIA that the project is still planned. Further, as the timeline for the project was not identified in publicly available records, it is assumed for the purpose of the CIA that the project might occur at the same time as construction and/or operation of the Yellowtail Development Project. Based on the coordinates provided in the project summary report, the onshore components of the mariculture project would be located approximately 10 kilometers (approximately 6 miles) southeast of the mouth of the Demerara River. The offshore component (growout area) would be located within a 24 km^2 (9.3 mi^2) area, with its closest boundary approximately 91 kilometers (approximately 56.5 miles) from the Yellowtail FPSO (Figure 10.4-1).

10.4.2.3. Oil and Gas Exploration

Three other companies that have conducted exploration activities offshore Guyana are assumed for the purpose of the CIA to have the potential to conduct additional exploration in the future: (1) Repsol in the Kanuku Block; (2) Tullow in the Orunduik Block; and (3) CGX in the Correntyne and Demerara blocks. The first well drilled by Repsol in the Kanuku Block reportedly did not encounter commercial hydrocarbons. Repsol has announced plans to drill another well offshore Guyana in 2022 (OilNOW 2021b). In 2019, Tullow announced its first oil discovery in the Orinduik Block. This was followed by another discovery in the same block. Tullow's website states that it is now working with its Joint Venture Partners on the overall prospect inventory and developing plans to unlock value from this acreage (Tullow Oil Undated). The government of Guyana granted an extension to the Tullow's term in the Orinduik Block until 2023 (Tomic 2021). As of the writing of this EIA, CGX was in the process of completing an exploration well in the Correntyne Block and announced that it had exercised its option to drill a second well. This is the first of two wells CGX is expected to spud this year. The second well is located

in the Demerara Block. CGX was granted a 1-year extension by the Guyana government last November on its schedule to conduct drilling operations in the Correntyne Block (OilNOW 2020).

Beyond the information described above, the Consultants have not made assumptions about the potential success of future exploration activities, and therefore are not assuming for the purpose of the CIA that a prolonged exploration program or any associated development projects will occur that could interact with the Yellowtail Development Project.

10.4.2.4. Hope Wind Farm

Project Summary

Hope Energy Development Inc. has submitted an EIA for the construction and operation of the first large-scale wind farm in Guyana along the East Coast of Demerara. Hope Energy Development Inc. has secured a 50-year land lease for the state-owned area of Hope Beach as well as private leases at Chapman's Grove, comprising a total area of 10.9 hectares (27 acres). Six wind turbines will be located 28 to 30 kilometers (17.9 to 19.2 miles) southeast of the center of Georgetown. Each turbine will be 105 meters (344 feet) in height above ground level and the maximum blade tip height during rotation will be 180 meters (590 feet) above ground level. For this project, no mangrove trees are expected to be removed from the coast to facilitate the construction of the wind turbines.

During construction, solid waste generated by the Project will include felled vegetation, excavated material, contaminated soil (in the event of spills and leaks of hydrocarbons), crates and packaging, waste paving material, cement and cement bags, timber, plywood, nails, screws for formwork and other carpentry, polyvinyl chloride pipes and fittings, and waste electrical ducting. All materials for civil and electrical works, as well as turbine equipment, will be transported by truck from Georgetown. Over the estimated 10-month construction period, an estimated 5,100 truckloads of materials and supplies will be transported to the site, averaging 25 truckloads per workday, with an estimated peak of up to 50 truckloads per day.

Project Schedule and Distance from the Yellowtail Development Project

The feasibility stage for the Hope Wind Farm is expected to be completed in the third quarter of 2021, pending receipt of a signed power purchase agreement and the Environmental Permit. The project is planned to be in operation by the end of 2022.

10.4.2.5. West Demerara Shore Base

Project Summary

TriStar Inc. has announced that it has received the regulatory approvals to move ahead with a planned shorebase facility known as the West Demerara Shore Base. The shorebase will occupy a 28.3-hectare (70-acre) site at Versailles, located on the West Bank of the Demerara River. When completed, the project will be a dedicated oil and gas shorebase with six berths (Thomas 2021).

Project Schedule and Distance from the Yellowtail Development Project

With construction of the facility set to start in 2021 and revetment works in process, it is anticipated that the project will be completed by the third quarter of 2023 (Thomas 2021). The shorebase will be located roughly opposite the existing Guyana Shore Base Inc., which the Yellowtail Project plans to use as a primary shorebase support facility (Stabroek News 2021).

10.4.2.6. Vreed-en-Hoop Port Facility

Project Summary

The Guyanese-owned consortium NRG Holdings Inc. has secured EPA approval for the Vreed-en-Hoop Port Facility at Foreshore, Plantation Best on the West Bank of Demerara. The project will construct and operate a facility that will include an offshore terminal; dry dock facility; a fabrication yard; offshore components; umbilical preparation and spooling yard; administrative buildings to house offices and modernized logistics centers; warehousing; area for a helipad; and a wharf, berths, and a dry dock. Located at Vreed-en-Hoop, Region Three, it will occupy some 400 hectares (988 acres) of coastal land. With the issuance of the Environmental Permit, NRG Holdings Inc. will have to submit an Environmental and Social Management Plan to the EPA within 4 months (OilNOW 2021a).

Project Schedule and Distance from the Yellowtail Development Project

The facility is proposed to be located at the western edge of the mouth of the Demerara River, proximal to where Yellowtail Project supply vessels will pass when entering/leaving Demerara Harbour. The Consultants could not identify information indicating the projected schedule for construction or operation of the facility. It is assumed for the purpose of this CIA that construction and/or operation could overlap the Yellowtail Project schedule.

10.4.3. External Drivers

10.4.3.1. Natural Hazards and Climate Change

The natural disaster risk profile for Guyana indicates that floods, droughts, and landslides pose the most significant risks for the country (UNISDR 2014; World Bank 2019). Of these, the primary natural hazards faced by the population are floods. The low-lying coastal plains in the northern areas of Regions 1 to 6 face severe risk of flooding. In the recent past, floods have produced significant health impacts, direct economic losses for agriculture, livestock, fisheries, and forestry industries, and significant damage to roads and other infrastructure. Floods can also potentially increase the transmission of water-borne diseases—such as typhoid fever, cholera, leptospirosis, and hepatitis A—and vector-borne diseases, such as malaria, dengue, and dengue hemorrhagic fever, yellow fever, and West Nile fever (WHO Undated).

The current scientific understanding of climate change is that the consequences of global climate change have the potential to impact Guyana's climatic conditions over the long term. A discussion of these potential consequences of climate change is provided in Section 6.1.2.3,

Current Scientific Understanding of Consequences of Climate Change. The information from this section has been considered in the development of the CIA.

10.4.3.2. Commercial and Artisanal Fishing

Marine fisheries and subsistence fishing occur throughout Guyana's coastal waters, from the shore to the edge of the continental shelf, approximately 150 kilometers (approximately 93 miles) from shore, although most fishing activity occurs well inshore from the edge of the continental shelf. There are four main types of marine fisheries in Guyana (see Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources), as differentiated by the species targeted, gear types used, and the depth of water where the fishery takes place:

- Industrial fisheries use trawls to target seabob, shrimp, and prawns, at depths of 13 to 16 meters (42.6 to 52.5 feet) primarily, but can also occur shallower or deeper depending on seasonal movements of the resource on the continental shelf.
- Semi-industrial fisheries use fish traps and lines to target red snapper and vermilion snapper at the edge of the continental shelf.
- Artisanal fisheries use gillnets, drift seines, Chinese seines, and other gear (e.g., Cadell line) to target shrimp and a mix of fish species, at depths of 0 to 28 meters (0 to 92 feet).
- Shark fisheries use trawls, gillnets, and hook and line to target sharks throughout the continental shelf waters, although these fisheries capture a number of species as bycatch.

Guyana's marine fishing activities are directed at commercializing its shrimp resources using trawlers, and its ground-fisheries (with the exception of the deepwater, semi-industrial, trap-based fishery) are based on wooden vessels and employ a variety of gear by artisanal fisherfolk. Fishing yields vary by season, with fisherfolk reporting the highest yields in June through September. From October to early February, catches are at their lowest due to seasonally colder waters coming from the north. There has been a declining trend for artisanal finfish, prawns, and seabob catches in recent years, although the recent decline follows an increasing trend for 2010 through 2012. The prawn industry has been voluntarily scaled back in response to limited catches resulting from overfishing in previous years, with approximately 15 Guyanese-registered boats in operation in 2016. Prawn fishing boats operate from the coast out to about 70 meters (230 feet) (ERM Personal Communication 2). Fishing by small vessels is generally focused along the coastlines of the vessels' respective landing sites. Larger artisanal vessels that have engine sizes of greater than 40 horsepower travel greater distances and have fishing trips of longer durations. There is limited exploitation of pelagic resources over the outer continental shelf and towards the continental slope.

Interviews with fisherfolk conducted as part of the Liza Phase 1 post-permit studies and the 2019 Participatory Fishing Survey indicated that gillnets are the most productive type of gear in the smaller-scale fisheries that operate closer to the coast, although gillnets are among the most susceptible gear types to fouling by sargassum, which presents an increasing and significant challenge to fisherfolk. The spread of mangrove vegetation along the shoreline and the dynamic

accretion and erosion of the Guyanese coastline as a result of natural forces also pose challenges for fisherfolk. This resultant loss of access to shore has caused some landing sites to close and fisherfolk to relocate to other landings sites.

Industrial fishing operators in Guyana are based mainly in Region 4 and have private wharves where their vessels dock. The large-scale commercial trawl fishery mainly targets seabob, a short-lived shallow water shrimp (*Xiphopenaeus kroyeri*), and various finfish species (MacDonald et al. 2015). This includes red snapper, shark, and tuna. The deepwater tuna fleet is currently at 12 vessels (ERM/EMC Personal Communication 4; ERM Personal Communication 26). The fishing industry is one of the most important direct and indirect economic drivers in Guyana (see Section 8.1.2, Existing Conditions—Socioeconomic Conditions). However, unselective fishing gear such as bottom trawls can cause harm to other fisheries and to the marine environment by catching juvenile fish and turtles, damaging the seafloor, and leading to overfishing. Bottom trawl nets can also harm coral reefs, sharks, and marine turtles (Stiles et al. 2010). The Liza Phase 1 post-permit studies documented some remnant coral growth in some areas on the continental shelf, and indicated the trawl fishery as a probable factor preventing recovery of Guyana's corals and other shallow benthic communities (ERM 2018).

10.5. VEC SELECTION AND DESCRIPTION

10.5.1. Selected Valued Environmental Components for Inclusion in the Cumulative Impact Assessment

All the potentially eligible VECs were analyzed against the following criteria: (1) confirmed to be valued by an identified stakeholder group; (2) reasonably expected to be potentially significantly impacted by the Project (i.e., at least one potential residual impact significance rating of **Minor** or above for a planned Project activity or at least one residual risk rating of **Moderate** or above for an unplanned event with a likelihood of at least **Possible**; and (3) reasonably expected to be potentially impacted by some combination of Other Projects and external drivers. Table 10.5-1 summarizes the VECs considered in the CIA.

Table 10.5-1: Selected VECs for Inclusion in CIA

VEC	Valued by Stakeholders	Potentially Affected by the Yellowtail Development Project [a]	Potentially Affected by One or More "Other Projects"	Potentially Affected by One or More "External Drivers"
Air Quality, Climate, and Climate Change	Yes	Yes	Yes	Yes
Marine Water Quality	Yes	Yes	Yes	Yes
Special Status Species	Yes	Yes	Yes	Yes
Marine Mammals	Yes	Yes	Yes	Yes
Marine Fish	Yes	Yes	Yes	Yes
Riverine Mammals	Yes	Yes	Yes	Yes
Ecological Balance and Ecosystems	Yes	Yes	Yes	Yes
Economic Conditions	Yes	Yes (potential adverse and positive)	Yes (potential adverse and positive)	Yes
Employment and Livelihoods	Yes	Yes (potential adverse and positive)	Yes (potential adverse and positive)	Yes
Community Health and Wellbeing	Yes	Yes	Yes	Yes
Marine Use and Transportation	Yes	Yes	Yes	Yes
Social Infrastructure and Services	Yes	Yes	Yes	Yes
Waste Management Infrastructure Capacity	Yes	Yes	Yes	No

[a] At least one potential residual impact significance rating of **Minor** or above for a planned Project activity or at least one residual risk rating of **Moderate** or above for an unplanned event with a likelihood of **Possible** or higher.

10.5.2. Valued Environmental Components Not Selected for Inclusion in Cumulative Impact Assessment

Several environmental and socioeconomic receptors or components were not selected as potentially eligible for the CIA, in all cases because they were not reasonably expected to be significantly impacted by the Yellowtail Development Project (i.e., at least one potential residual impact significance rating of **Minor** or above for a planned Project activity or at least one residual risk rating of **Moderate** or above for an unplanned event with a likelihood of **Possible** or higher)—and in some cases were also not reasonably expected to be potentially impacted by some combination of Other Projects or External Drivers. Table 10.5-2 presents the components that were not selected as VECs for the CIA.

Table 10.5-2: VECs Not Selected for Inclusion in CIA

Potential VEC	Valued by Stakeholders	Potentially Affected by Yellowtail Development Project [a]	Potentially Affected by One or More "Other Projects"	Potentially Affected By One or More "External Drivers"
Sound (Airborne)	Yes	No	No	No
Marine Geology/Sediments	Yes	No	No	Yes
Protected Areas	Yes	No	No	Yes
Coastal Wildlife	Yes	No	No	Yes
Coastal Habitats	Yes	No	No	Yes
Marine Benthos	Yes	No	No	Yes
Marine Turtles [b]	Yes	No	No	Yes
Seabirds [b]	Yes	No	No	Yes
Cultural Heritage	Yes	No	No	No
Land Use	Yes	No	No	Yes
Ecosystem Services	Yes	No	No	Yes
Indigenous Peoples	Yes	No	No	Yes

[a] At least one potential residual impact significance rating of **Minor** or above for a planned Project activity or at least one residual risk rating of **Moderate** or above for an unplanned event with a likelihood of **Possible** or higher.
[b] Marine turtles and seabirds were retained for further assessment as discussions of individual taxon groups with special status species are provided in lieu of special status species as a single resource.

10.5.3. Potential Impacts from Other Projects

Table 10.5-3 provides a list of the Other Projects and a summary of their potential impacts. Some of the projects are other EEPGL developments in the area and there is some level of detailed preliminary information to inform the CIA; however, detailed information is not available for all of the Other Non-EEPGL Projects. The identified Other Projects that have a similar nature, such as the other EEPGL exploration and development projects, other operator exploration drilling, and new shorebase and port facilities are grouped and their potential impacts discussed together. Potential impacts are annotated with a "C" and/or "O" to indicate whether the impact is associated with construction (C) or operation (O) stages. For this purpose drilling is categorized as "construction."

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Table 10.5-3: Potential Impacts from Other Projects

Other EEPGL Oil and Gas Exploration and Development Projects [a]	Non-EEPGL Oil and Gas Exploration Projects [b]	Fiber Optic Cable Project	Guyana Office Complex Project	Gas to Energy Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture Project	Hope Wind Farm	New Shorebase and Port Facilities [c]
Air Quality, Climate and Climate Change: Potential impacts include increased concentrations of criteria pollutant emissions from offshore sources, potentially resulting in health impacts to onshore receptors (C,O), and increased GHG emissions (C,O). **Marine Water Quality:** Potential impacts include increased TSS concentrations in water column from drilling (C) and changes in water quality and temperature from liquid effluent discharges (O). **Special Status Species:** [see taxon-specific receptors below] **Seabirds:** Potential impacts include direct mortality or injury from attraction to offshore Project facilities (C,O) and light and sound disturbance from Project activities (C,O). A positive benefit is the use of major vessels as a resting place or attractant of prey (O). **Marine Mammals:** Potential impacts include exposure to permitted discharges (C,O), acoustic injury from underwater sound exposure (C), and underwater sound disturbance leading to deviation from the area (C,O). Potential risks include vessel strikes (an unplanned event) (C,O). **Marine Turtles:** Potential impacts include disturbance from artificial lighting (O), displacement	**Air Quality, Climate and Climate Change:** Potential impacts include increased concentrations of criteria pollutant emissions from offshore sources, potentially resulting in health impacts to onshore receptors (C), and increased GHG emissions (C). **Marine Water Quality:** Potential impacts include increased TSS concentrations in water column from drilling (C). **Special Status Species:** [see taxon-specific receptors below] **Seabirds:** Potential impacts include direct mortality or injury from attraction to offshore project facilities (C,O) and light and sound disturbance from project activities (C,O). A positive benefit is the use of major vessels as a resting place or attractant of prey (O). **Marine Mammals:** Potential impacts include exposure to permitted discharges (C), acoustic injury from underwater sound exposure (C), and underwater sound disturbance leading to deviation from the area (C). Potential risks include vessel strikes (an unplanned event) (C).	**Air Quality, Climate and Climate Change:** Potential impacts include increased concentrations of criteria pollutant emissions from construction activities, potentially resulting in health impacts to onshore receptors, and increased GHG emissions from construction activities (C). **Marine Water Quality:** Potential impacts include effluent discharges from installation vessels, and temporary increases in TSS concentration during trenching or jetting to bury offshore cable (C). **Special Status Species:** [see taxon-specific receptors below] **Seabirds:** Potential impacts include direct mortality or injury from attraction to offshore project facilities (C) and light and sound disturbance from project activities (C). **Marine Mammals:** Potential impacts include exposure to permitted discharges (C). Potential risks include vessel strikes (an unplanned event) (C). **Marine Turtles:** Potential impacts include displacement	**Air Quality, Climate and Climate Change:** Potential impacts include increased concentrations of criteria pollutant emissions from construction activities, potentially resulting in health impacts to onshore receptors (C), and increased GHG emissions from construction activities (C). **Marine Water Quality:** No potential impacts anticipated. **Special Status Species:** [see taxon-specific receptors below] **Seabirds:** No potential impacts anticipated. **Marine Mammals:** No potential impacts anticipated. **Marine Turtles:** No potential impacts anticipated. **Marine Fish:** No potential impacts anticipated. **Riverine Mammals:** No potential impacts anticipated. **Ecological Balance and Ecosystems:** No potential impacts anticipated.	**Air Quality, Climate and Climate Change:** Potential impacts include increased concentrations of criteria pollutant emissions from onshore and offshore sources, potentially resulting in health impacts to onshore receptors (C,O) and increased GHG emissions (C,O). **Marine Water Quality:** Potential impacts include temporary increases in TSS concentrations during pipeline installation (C) and discharges to marine waters from hydrotesting of pipeline segments (C). **Special Status Species:** [see taxon-specific receptors below] **Seabirds:** Potential impacts include direct mortality or injury from attraction to offshore project facilities (C) and light and sound disturbance from project activities (C). **Marine Mammals:** Potential impacts include exposure to permitted discharges and underwater sound disturbance leading to deviation from the area (C). Potential risks include vessel strikes (an unplanned event) (C). **Marine Turtles:** Potential impacts include exposure to permitted discharges and underwater sound disturbance leading to deviation from the area	**Air Quality, Climate and Climate Change:** Potential impacts include increased concentrations of criteria pollutant emissions from construction activities, potentially resulting in health impacts to onshore receptors (C), and increased GHG emissions from construction activities (C). **Marine Water Quality:** Potential impacts include temporary increases in TSS concentrations during bridge construction (C). **Special Status Species:** [see taxon-specific receptors below] **Seabirds:** No potential impacts anticipated. **Marine Mammals:** No potential impacts anticipated. **Marine Turtles:** No potential impacts anticipated. **Marine Fish:** Potential impacts include auditory impacts on fish (pelagic species) from vessel activity (C), disturbance and distribution and habitat changes for demersal species from altered water quality during construction (C). **Riverine Mammals:** Potential impacts include behavioral changes or displacement as a result of increased vessel traffic within Georgetown	**Air Quality, Climate and Climate Change:** Potential impacts include increased concentrations of criteria pollutant emissions from construction activities, potentially resulting in health impacts on onshore receptors (C,O), and increased GHG emissions from construction activities (C,O). **Marine Water Quality:** Potential impacts include changes in water quality due to the activities associated with the proposed culture of a significant biomass of fish, including increase in ammonia and nitrates, resulting from protein metabolism by the cultured species (O). **Special Status Species:** [see taxon-specific receptors below] **Seabirds:** No potential impacts anticipated. **Marine Mammals:** No potential impacts anticipated. **Marine Turtles:** No potential impacts anticipated. **Marine Fish:** Potential impacts include predation of fingerlings of various species of wild fish that will enter the pens, which are used as growing structures for the fish. Once in the cages, it is likely that these fingerlings will be subject	**Air Quality, Climate and Climate Change:** Potential impacts include increased concentrations of criteria pollutant emissions from construction activities, potentially resulting in health impacts to onshore receptors (C), and increased GHG emissions from construction activities (C). **Marine Water Quality:** No potential impacts anticipated. **Special Status Species:** [see taxon-specific receptors below] **Seabirds:** Potential impacts include potential attraction and resultant mortality or injury from collisions with wind turbines and disturbance, although the two special status seabirds are unlikely to be present in the area near the wind turbines (C.O). **Marine Mammals:** No potential impacts anticipated. **Marine Turtles:** No potential impacts anticipated. **Marine Fish:** No potential impacts anticipated. **Riverine Mammals:** No potential impacts anticipated.	**Air Quality, Climate and Climate Change:** Potential impacts include increased concentrations of criteria pollutant emissions from construction and operation activities, potentially resulting in health impacts to onshore receptors (C,O), and increased GHG emissions from construction and operation activities (C,O). **Marine Water Quality:** No potential impacts anticipated. **Special Status Species:** [see taxon-specific receptors below] **Seabirds:** Potential impacts include potential light and sound disturbance during nearshore construction (C). **Marine Mammals:** No potential impacts anticipated. **Marine Turtles:** No potential impacts anticipated. **Marine Fish:** Potential impacts include auditory impacts on fish (pelagic species) from vessel activity (C), disturbance and distribution and habitat changes from altered water quality during construction (C). **Riverine Mammals:** Potential impacts include behavioral changes or displacement as a result

Other EEPGL Oil and Gas Exploration and Development Projects [a]	Non-EEPGL Oil and Gas Exploration Projects [b]	Fiber Optic Cable Project	Guyana Office Complex Project	Gas to Energy Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture Project	Hope Wind Farm	New Shorebase and Port Facilities [c]
from habitat due to disturbance from vessel activity (C,O), acoustic injury from sound exposure (C), and exposure to permitted discharges (O). Potential risks include vessel strikes (an unplanned event) (C,O). **Marine Fish:** Potential impacts include auditory impacts on fish (pelagic species) from vessel activity (C,O), disturbance from or attraction to offshore lighting that would affect pelagic species (O), auditory impacts on demersal species from pile driving and VSP (C), entrainment of pelagic species in water intakes (O), and distribution and habitat changes for demersal species from altered water quality (C). **Riverine Mammals:** Potential impacts include behavioral changes or displacement as a result of increased vessel traffic within Georgetown Harbour (C,O). Potential risks include vessel strikes (an unplanned event) (C,O). **Ecological Balance and Ecosystems:** Potential impacts include introduction of invasive species via ballast water discharges (C,O), changes in marine nutrient cycle resulting in localized and temporary changes in phytoplankton species distribution (C,O), and impacts on gene flow (C,O). **Economic Conditions:** Potential impacts include adverse impacts on potential for increased cost	**Marine Turtles:** Potential impacts include displacement from habitat due to disturbance from vessel activity (C), and acoustic injury from sound exposure (C). Potential risks include vessel strikes (an unplanned event) (C,O). **Marine Fish:** Potential impacts include auditory impacts on fish (pelagic species) from vessel activity (C), auditory impacts on demersal species from pile driving and VSP (C), and distribution and habitat changes for demersal species from altered water quality (C). **Riverine Mammals:** Potential impacts include behavioral changes or displacement as a result of increased vessel traffic within Georgetown Harbour (C). Potential risks include vessel strikes (an unplanned event) (C,O). **Ecological Balance and Ecosystems:** Potential impacts include introduction of invasive species via ballast water discharges (C), changes in marine nutrient cycle resulting in localized and temporary changes in phytoplankton species distribution (C), and impacts on gene flow (C). **Economic Conditions:** Potential impacts include adverse impacts on potential for	from habitat due to disturbance from vessel activity (C), and exposure to permitted discharges (C). Potential risks include vessel strikes (an unplanned event) (C). **Marine Fish:** Potential impacts include temporary distribution and habitat changes for demersal species from altered water quality during laying and burial of offshore cable (C). **Riverine Mammals:** Potential impacts include behavioral changes or displacement as a result of increased vessel traffic within Georgetown Harbour (C). Potential risks include vessel strikes (an unplanned event) (C). **Ecological Balance and Ecosystems:** No potential impacts anticipated. **Economic Conditions:** No potential impacts anticipated. **Employment and Livelihoods:** Potential impacts include temporary impacts on fishing livelihoods as a result of marine safety exclusion zones during construction (C). **Community Health and Wellbeing:** No potential impacts anticipated.	**Economic Conditions:** No potential impacts anticipated. **Employment and Livelihoods:** No potential impacts anticipated. **Community Health and Wellbeing:** No potential impacts anticipated. **Marine Use and Transportation:** No potential impacts anticipated. **Social Infrastructure and Services:** Potential impacts include increase in traffic congestion (C,O). **Waste Management Infrastructure Capacity:** Potential impacts include increased burden on waste management infrastructure capacity for local landfill facilities (C,O).	(C). Potential risks include vessel strikes (an unplanned event) (C). **Marine Fish:** Potential impacts include auditory impacts on fish (pelagic species) from vessel activity (C), disturbance and distribution and habitat changes for demersal species from altered water quality during construction (C). **Riverine Mammals:** Potential impacts include behavioral changes or displacement as a result of increased vessel traffic within Georgetown Harbour (C,O) and discharge of sediment to canals or drainage features that discharge to the Demerara River (C,O). Potential risks include vessel strikes (an unplanned event) (C,O). **Ecological Balance and Ecosystems:** Potential impacts include localized changes in marine and riverine nutrient cycles, gene flow, and biodiversity (C). **Economic Conditions:** Potential benefits include reduced cost of energy and increased reliability and associated indirect economic benefits (O). **Employment and Livelihoods:** Potential impacts include temporary impacts on fishing livelihoods as a result of marine safety exclusion zones during construction (C). Potential benefits include increased employment, local business activity,	Harbour (C,O). Potential risks include vessel strikes (an unplanned event) (C,O). **Ecological Balance and Ecosystems:** No potential impacts anticipated. **Economic Conditions:** No potential impacts anticipated. **Employment and Livelihoods:** No potential impacts anticipated. **Community Health and Wellbeing:** No potential impacts anticipated. **Marine Use and Transportation:** Potential impacts include increased vessel traffic within Georgetown Harbour (C). **Social Infrastructure and Services:** Potential impacts include increased demand for use of lodging, leading to reduced availability and/or increased cost (C), increase in traffic congestion (C), and potential resettlement at shore connections for bridge (C). **Waste Management Infrastructure Capacity:** Potential impacts include increased burden on waste management infrastructure capacity for local landfill facilities and hazardous waste management facilities (C).	to predation. Four of the five species that would be grown are predaceous, and one is omnivorous (O). **Riverine Mammals:** No potential impacts anticipated. **Ecological Balance and Ecosystems:** Potential impacts include potential release of alien species into the natural environment (O), potential loss of genetic resources due to collection of larvae, fry, or juveniles for aquaculture production (O), potential release of artificially propagated seed into the wild (O), and development of antibiotic resistance in pathogenic bacteria that could then spread from farms to wild stock (O). **Economic Conditions:** No potential impacts anticipated. **Employment and Livelihoods:** No potential impacts anticipated. **Community Health and Wellbeing:** No potential impacts anticipated. **Marine Use and Transportation:** Potential impacts include increased vessel traffic between Georgetown Harbour and the PDA (C).	**Ecological Balance and Ecosystems:** No potential impacts anticipated. **Economic Conditions:** No potential impacts anticipated. **Employment and Livelihoods:** No potential impacts anticipated. **Community Health and Wellbeing:** No potential impacts anticipated. **Marine Use and Transportation:** No potential impacts anticipated. **Social Infrastructure and Services:** Potential impacts include increased demand for use of lodging leading to reduced availability and/or increased cost (C), and increase in traffic congestion (C). **Waste Management Infrastructure Capacity:** Potential impacts include increased burden on waste management infrastructure capacity for local landfill facilities and hazardous waste management facilities (C).	of increased vessel traffic within Georgetown Harbour (C,O). Potential risks include vessel strikes (an unplanned event) (C,O). **Ecological Balance and Ecosystems:** No potential impacts anticipated. **Economic Conditions:** No potential impacts anticipated. **Employment and Livelihoods:** No potential impacts anticipated. **Community Health and Wellbeing:** No potential impacts anticipated. **Marine Use and Transportation:** Potential impacts include increased vessel traffic in Georgetown Harbour (C,O). **Social Infrastructure and Services:** Potential impacts include increased demand for use of lodging leading to reduced availability and/or increased cost (C), and increase in traffic congestion (C,O). **Waste Management Infrastructure Capacity:** Potential impacts include increased burden on waste management infrastructure capacity for local landfill facilities and hazardous waste management facilities (C,O).

Other EEPGL Oil and Gas Exploration and Development Projects [a]	Non-EEPGL Oil and Gas Exploration Projects [b]	Fiber Optic Cable Project	Guyana Office Complex Project	Gas to Energy Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture Project	Hope Wind Farm	New Shorebase and Port Facilities [c]
of living and potential for competition with other local businesses for qualified workers (C,O). Potential benefits include increased government revenues and increased employment, increased local business activity (C,O). **Employment and Livelihoods:** Potential impacts include adverse impacts on fishing livelihoods as a result of marine safety exclusion zones within the PDA for commercial fishing operations and interference with subsistence fishing (C,O). Potential benefits include increased employment, local business activity, and household income (O). **Community Health and Wellbeing:** Potential impacts include increased risk of communicable disease transmission (C,O), impacts on public safety (C,O), public anxiety over oil and gas sector risks (O), and reduced access to emergency and health services (C,O). **Marine Use and Transportation:** Potential impacts include increased vessel traffic between Georgetown Harbour and the PDA (C,O), reduced availability of ocean surface areas for non-Project activities (C,O), and interference with commercial cargo, commercial fishing, and subsistence fishing vessels (C,O).	increased cost of living and potential for competition with other local businesses for qualified workers (C,O). Potential benefits include increased government revenues and increased employment, increased local business activity (C,O). **Employment and Livelihoods:** Potential impacts include adverse impacts on fishing livelihoods as a result of marine safety exclusion zones within the PDA for commercial fishing operations and interference with subsistence fishing (C). **Community Health and Wellbeing:** Potential impacts include increased risk of communicable disease transmission (C), impacts on public safety (C), and reduced access to emergency and health services (C). **Marine Use and Transportation:** Potential impacts include increased vessel traffic between Georgetown Harbour and the PDA (C), reduced availability of ocean surface areas for non-Project activities (C), and interference with commercial cargo, commercial fishing, and subsistence fishing vessels (C). **Social Infrastructure and Services:** Potential impacts include Increased demand for use of lodging, leading to	**Marine Use and Transportation:** Potential impacts include increased vessel traffic between Georgetown Harbour and the PDA during offshore construction (C) and temporary interference with subsistence fishing vessels during construction (C). **Social Infrastructure and Services:** No potential impacts anticipated. **Waste Management Infrastructure Capacity:** Potential impacts include increased burden on waste management infrastructure capacity for local landfill facilities during construction (C).		and household income (O). **Community Health and Wellbeing:** Potential impacts include increased risk of communicable disease transmission (C), impacts on public safety (C), public anxiety over oil and gas sector risks (O), and reduced access to emergency and health services (C,O). **Marine Use and Transportation:** Potential impacts include increased vessel traffic between Georgetown Harbour and the PDA (C,O), and temporary interference with commercial cargo, commercial fishing, and subsistence fishing vessels during construction of offshore pipeline (C). **Social Infrastructure and Services:** Potential impacts include increased demand for use of lodging leading to reduced availability and/or increased cost (C), decreased availability/increased cost of housing and utilities (C), and increase in traffic congestion (C,O). **Waste Management Infrastructure Capacity:** Potential impacts include increased burden on waste management infrastructure capacity for local landfill facilities and hazardous waste management facilities (C,O).				

Other EEPGL Oil and Gas Exploration and Development Projects [a]	Non-EEPGL Oil and Gas Exploration Projects [b]	Fiber Optic Cable Project	Guyana Office Complex Project	Gas to Energy Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture Project	Hope Wind Farm	New Shorebase and Port Facilities [c]
Social Infrastructure and Services: Potential impacts include increased demand for use of lodging leading to reduced availability and/or increased cost (C), decreased availability/increased cost of housing and utilities (C), increase in traffic congestion (C,O), and increase in heliport congestion (C,O). **Waste Management Infrastructure Capacity:** Potential impacts include increased burden on waste management infrastructure capacity for local landfill facilities and hazardous waste management facilities (C,O).	reduced availability and/or increased cost (C), decreased availability/increased cost of housing and utilities (C), increase in traffic congestion (C), and increase in heliport congestion (C). **Waste Management Infrastructure Capacity:** Potential impacts include increased burden on waste management infrastructure capacity for local landfill facilities and hazardous waste management facilities (C).							

C = Construction; O = Operation; VSP = Vertical Seismic Profile
[a] Exploration drilling by EEPGL; Liza Phase 1; Liza Phase 2; Payara, FPSO #5; and FPSO #6 Development Projects
[b] Exploration drilling by Repsol, Tullow, and CGX
[c] West Demerara Shorebase and Vreed-en-Hoop Port Facility

10.5.4. Valued Environmental Component Description

The existing conditions sections of this EIA present the existing conditions of the selected VECs, as well as those taxon-specific VECs not selected, but discussed in lieu of Special Status Species (i.e., Marine Turtles and Seabirds); please refer to the following sections for details on the current status of each component:

- Air Quality, Climate, and Climate Change: Section 6.1.2
- Marine Water Quality: Section 6.4.2
- Special Status Species: Section 7.1.2
- Seabirds: Section 7.4.2
- Marine Mammals: Section 7.5.2
- Riverine Mammals: Section 7.6.2
- Marine Turtles: Section 7.7.2
- Marine Fish: Section 7.8.2
- Marine Benthos: Section 7.9.2
- Ecological Balance and Ecosystems: Section 7.10.2
- Economic Conditions: Section 8.1.2
- Employment and Livelihoods: Section 8.2.2
- Community Health and Wellbeing: Section 8.3.2
- Marine Use and Transportation: Section 8.4.2
- Social Infrastructure and Services: Section 8.5.2
- Waste Management Infrastructure Capacity: Section 8.6.2

10.6. Assessment of Cumulative Impacts on VECs

In addition to the Project-only analyses conducted for the Yellowtail Project (see prior sections of the EIA), the following analyses were conducted:

- Air quality dispersion modeling was conducted for cumulative emissions from the Liza Phase 1, Liza Phase 2, Payara, and Yellowtail Development Projects, as well as ongoing exploration drilling (see Section 10.6.1.1, Air Quality).
- An inventory of cumulative GHG emissions from all of EEPGL's development projects during the projected Yellowtail Development Project life (at least 20 years) was developed (see Section 10.6.1.2, Climate and Climate Change).
- Analysis of cumulative effects was conducted for potential water quality impacts resulting from simultaneous production operations discharges from the Liza Phase 1, Liza Phase 2, Payara, and Yellowtail FPSOs (see Section 10.6.2, Water Quality Modeling for Simultaneous Operations).
- Assessment of cumulative waste management infrastructure capacity demands for all of EEPGL's projected operations at the time the Yellowtail Development Project will come online was conducted (see Section 10.6.3, Waste Management).

- Traffic congestion analysis was conducted for all of EEPGL's projected operations at the time the Yellowtail Development Project will come online (see Section 10.6.4, Traffic Impact Modeling for Simultaneous Operations).

10.6.1. Air Quality, Climate, and Climate Change

10.6.1.1. Air Quality

Emissions generated by the Project generally emanate from two source categories: (1) specific point sources such as the power-generating units and diesel engines on drill ships and on the FPSO, and flares used (non-routinely) to combust associated gas not consumed as fuel gas on the FPSO or re-injected; and (2) general area sources such as support vessels, construction vessels, tug boats, and helicopters.

Air dispersion modeling was carried out to assess air quality impacts for onshore human receptors. Additionally, in the Emissions Inventory and Air Quality Modeling Report (Appendix G), the cumulative impacts from the following EEPGL offshore activities (in addition to those from the Yellowtail Project) were modeled:

- Exploration drilling through end of 2028;
- Liza Phase 1 Development Project (FPSO operation);
- Liza Phase 2 Development Project (FPSO operation);
- Payara Development Project (development well drilling; installation, commissioning, and start-up; and FPSO operation);
- A fifth development project (FPSO #5; development well drilling; installation, commissioning, and start-up; and FPSO operation); and
- A sixth development project FPSO #6; development well drilling; installation, commissioning, and start-up; and FPSO operation).

The modeling predicted the maximum onshore concentrations from the Yellowtail Project combined with the above-referenced EEPGL activities to be no more than 28.4 percent of the ambient air quality guidelines for nitrogen dioxide, and no more than 3.9 percent for any of the other parameters subjected to modeling.

10.6.1.2. Climate and Climate Change

Considering the Project and the other offshore EEPGL exploration and development activities included in the scope of the CIA[5], the peak annual cumulative GHG emissions across the considered EEPGL activities are presented on Figure 10.6-1. The primary sources of GHG emissions are the combustion turbines and flares on the FPSOs, with smaller amounts from other fuel combustion sources. GHG emissions result from products of combustion of various

[5] GHG emission estimates are not included for the FOC Project and GOC Project because the GHG emissions for the projects are expected to be *de minimis* in comparison to production operations from development projects. GHG emissions estimates are not included for the GTE Project because the specific equipment for the Project has not yet been determined.

fuel components based on the potential for each component to contribute to GHG emissions and the emissions of other emitted GHG compounds such as methane and nitrous oxides. As noted in Section 6.1, Air Quality, Climate, and Climate Change, emission factors from the AP-42 document were used to calculate combustion-related GHG emissions.

As shown on Figure 10.6-1, applying the Design Case emissions for Yellowtail, FPSO #5, and FPSO #6, cumulative GHG emissions are projected to increase through 2031 to a peak of approximately 7,800 kilotonnes per year, and then decrease steadily to approximately 3,300 kilotonnes per year by the end of the projected Yellowtail 20-year life cycle, as predicted production levels gradually decrease for the six assessed development projects.

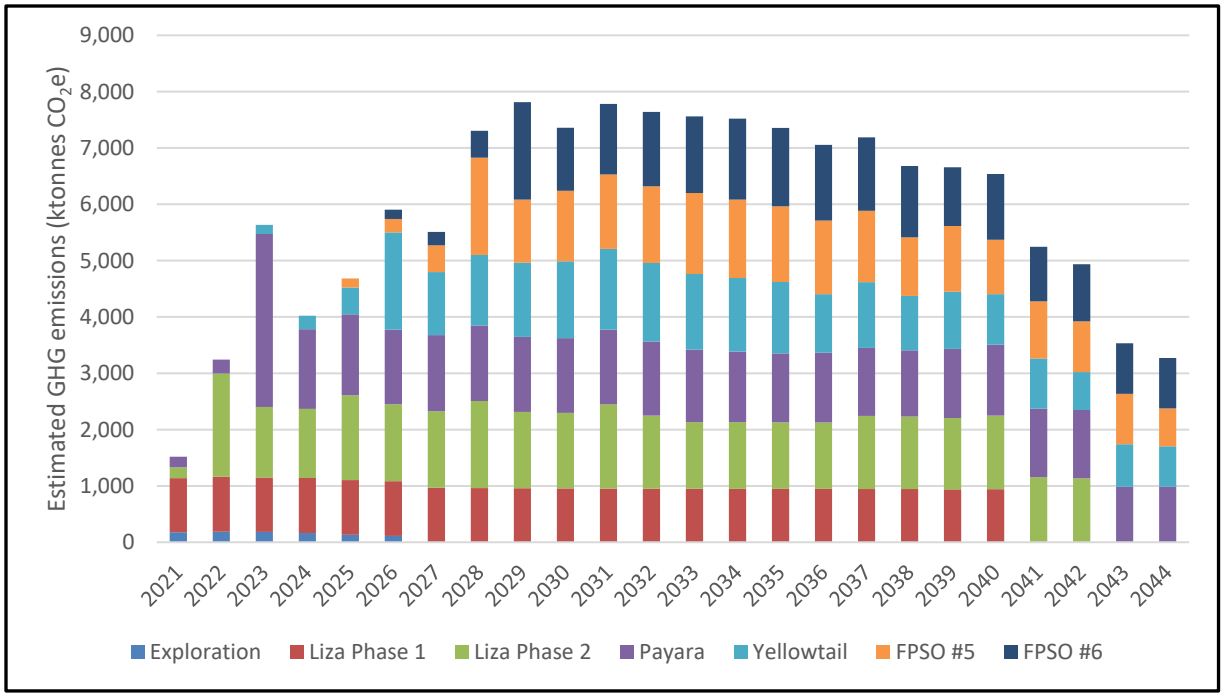

Figure 10.6-1: Summary of Estimated Annual GHG Emissions—Cumulative EEPGL Exploration and Development Activities

As described in Section 6.1, Air Quality, Climate, and Climate Change, Guyana published its Second National Communication on Climate Change in 2012 (Government of Guyana 2012) and it reported a net sink of GHGs (meaning its national "removals" exceeded its national emissions). This document provided country-level GHG estimates, the most recent of which was for 2004. For 2004, the document states that reported net annual removals for Guyana were approximately 56.9 million tonnes of carbon dioxide equivalent (CO_2e), comprising total removals of approximately 61.5 million tonnes per year of CO_2e and total emissions of approximately 4.7 million tonnes per year of CO_2e. Considering these figures, although the peak annual cumulative GHG emissions from the EEPGL activities considered above (i.e., exploration drilling through 2028 and six operating development projects by 2027) would represent an approximately 167 percent increase in emissions at a country level (above reported 2004 levels), Guyana's net removals (from reported 2004 levels) would decrease from

56.9 million tonnes of CO_2e per year to approximately 49.1 million tonnes of CO_2e per year (i.e., an approximately 14 percent decrease) from cumulative EEPGL emissions at the peak of the Yellowtail Project life cycle.

10.6.2. Water Quality Modeling for Simultaneous Operations

Although the Yellowtail Project's FPSO will be approximately 30.8 kilometers (19.1 miles) away from the Liza Phase 1 Project FPSO, 22.5 kilometers (14.0 miles) away from the Liza Phase 2 Project FPSO, and 41 kilometers (25.5 miles) away from the Payara Project FPSO, modeling was conducted to assess whether there is a potential for cumulative impacts on water quality due to simultaneous offshore discharges from the respective developments. The modeling included the major operational discharges and assessed the potential for plumes from the four FPSOs to overlap and result in cumulative impacts. None of the plume constituents that were included in the assessment (oil and grease, hypochlorite, and corrosion inhibitor) showed predicted overlaps even when mapping to extremely low levels (0.04 milligrams per liter [mg/L], 0.0005 mg/L, and 0.05 mg/L, respectively). The only constituent with a reference guideline is temperature (less than 3 degrees Celsius (ºC) rise (5.4 degrees Fahrenheit [ºF]) above ambient at 100 meters [328 feet] from the discharge). With all four of these FPSOs operating simultaneously, and each FPSO discharging both produced water and cooling water (both of which add a thermal load), there was no predicted overlap in plumes, even when the "plume" from each FPSO was defined as a temperature rise above ambient as low as 0.05ºC (0.09ºF).

An assessment was also performed to evaluate the potential for cumulative impacts (overlap of cuttings deposition or TSS plume) from simultaneous drilling activities. Results of the drill cuttings modeling indicates that even the closest distance between a Project well and a non-Project well exceeds the distance a cuttings deposition footprint or TSS plume would extend from a well. Furthermore, for a combined deposition to result in cumulative impacts—even if the wells were close enough together to have overlapping deposition—another drilling operation would have to occur during the same 30-day period as a Yellowtail development well drilling operation. It is not likely that two such wells in such close proximity would be drilled within the same 30-day period. Similarly, the TSS plumes from drilling are highly ephemeral and will disperse rapidly under the ambient currents, resulting in a very low potential for any overlap with a TSS plume from another nearby drilling operation.

A detailed discussion of the methodology and results is presented in Appendix C, Water Quality Modeling Report.

10.6.3. Waste Management

Considering the Project and the other offshore EEPGL activities included in the scope of the CIA (i.e., exploration through 2028, Liza Phase 1, Liza Phase 2, Payara, Yellowtail, FPSO #5, and FPSO #6 development projects, FOC Project, GOC Project, and GTE Project operational

by 2027)[6], the types and estimated quantities of wastes that will be transported to shore for management are summarized below in Table 10.6-1.

Table 10.6-1: Summary of Estimated Annual Project Waste Generation and Management Methods—Cumulative EEPGL Activities

Waste Generated by Category	Volume by Year/Metric Tonnes [a]									
	2023	2024	2025	2026	2027	2028	2029	2030	2031–2032	2033–2044
Non-Hazardous wastes (total) [b, c]	5,370	4,830	5,290	5,240	4,940	4,810	3,310	1,750	3,310	1,750
Hazardous wastes (total) [b, d]	4,310	3,270	5,970	5,070	3,090	1,790	1,180	580	1,180	580

[a] The annual totals reflect the current preliminary Project schedules and the production profiles for development projects and exploration drilling, which could change. The Yellowtail portion of the annual totals conservatively assumes drilling up to 2032.
[b] Totals may not sum exactly due to rounding.
[c] Includes wastes that will be directly shipped to an approved landfill and wastes that can be recycled, reclaimed, or reused. Volumes include estimated quantities of residue from treatment of hazardous waste.
[d] Includes wastes that are treated to produce residual non-hazardous effluent than can be discharged through permitted outfalls and wastes that are treated to produce residual non-hazardous solid wastes that can then be recycled, reclaimed, reused, or transported for disposal in an approved landfill.

The cumulative projected peak waste generation is on the order of approximately 940 tonnes per month (non-hazardous and hazardous combined). Conservatively assuming all of the non-hazardous waste and all of the treated hazardous waste (assuming no reduction in mass during treatment) ultimately is disposed in a non-hazardous landfill, this represents approximately 6.2 percent of the total current demand on Georgetown-based landfill facilities (on the order of approximately 15,000 tonnes per month). Taking into consideration the opening of Cell 2, the reasonably anticipated development of additional cells at the Haags Bosch Landfill (HBL), and the limited percent contribution of the Project, this represents a relatively low level of impact on non-hazardous waste management infrastructure capacity for the longer-term (up to 10 years). New landfill development in the region may be appropriate for consideration going forward.

In the absence of other oil and gas/industrial operations exerting a significant increase in the demand on Georgetown-based hazardous waste treatment facilities, the cumulative projected peak hazardous waste generation (approximately 500 tonnes per month) would represent a significant portion of the total demand for Georgetown-based hazardous waste treatment facilities. However, given the recent and ongoing expansion of hazardous waste management capacity in Georgetown, this waste generation rate is not expected to overburden the treatment capacity.

[6] Waste estimates are not included for the FOC Project because the construction stage is expected to be finished by the time the Yellowtail Project activities begin and the volume of waste generated for this project during its operation stage is expected to be *de minimis*. The Consultants were unable to identify publicly available waste generation estimates for the non-EEPGL projects included in the CIA.

10.6.4. Traffic Impact Modeling for Simultaneous Operations

As described in Section 8.5, Social Infrastructure and Services, in 2019, the traffic consultancy CARITRANS conducted Level of Service (LOS) modeling focused on road segments across Georgetown. The LOS modeling conducted by CARITRANS for the Project was focused on 47 road segments across Georgetown; these include those intersections anticipated to be among the road segments more heavily used by EEPGL-related vehicle movements. The study modeled two scenarios in 2026, selected to represent a time when the Yellowtail development is planned to be in production operations, with continued development well drilling occurring. The scenarios analyzed for 2026 included:

- Baseline conditions (i.e., without EEPGL-related vehicle movements) factoring in growth in 2018/2019 measured baseline conditions at a rate of 5 percent per year; and
- Baseline conditions factoring in growth in 2018/2019 measured baseline conditions at a rate of 5 percent per year, plus additional EEPGL-related vehicle movements anticipated in 2026.

Modeling was conducted for total estimated additional EEPGL-related vehicle movements in 2026, as opposed to Yellowtail-only vehicle movements, because existing data and future estimates regarding EEPGL-related vehicle movements are not readily divisible by specific Project activity. In this sense, the modeling reflects a cumulative impact analysis.

To provide a basis for CARITRANS to simulate additional EEPGL-related vehicle movements in the LOS modeling, the Consultants worked with EEPGL to develop projections of EEPGL-related vehicle movements for 2026. Vehicle movement estimates were developed from the following:

- Recorded EEPGL “fleet” vehicle movements over the period of 4 February 2019 through 28 April 2019 (EEPGL tracks the movements of its fleet vehicles—which are used for transport of EEPGL staff around Georgetown—using global positioning system devices); and
- Estimates of non-personnel EEPGL-related vehicle movements (i.e., for material, supply, waste transports, etc.).

The full report containing the results of LOS modeling for these scenarios is included as Appendix T, Traffic Impact Assessment.

Considering both peak periods (a.m. and p.m.), all of the directions (e.g., northbound, southbound) and all of the turning movements (i.e., left, right, through) at each intersection, modeling predicted a total of 710 LOS ratings for each scenario. Comparing the results for the “without EEPGL vehicle movements” and “with EEPGL vehicle movements” scenarios, the LOS modeling predicted that the addition of projected cumulative EEPGL-related vehicle trips in 2026 would potentially shift an LOS rating from an “acceptable” LOS rating (i.e., LOS A-D) to a lower “acceptable” LOS rating for 29 out of 710 movements (approximately 4 percent) and from “acceptable” to “unacceptable” (i.e., LOS E-F) for 15 of the 710 movements (approximately 2 percent). This confirms that the additional cumulative EEPGL-related vehicle trip counts in

2026 are not expected to meaningfully change overall LOS ratings across the study intersections.

10.6.5. Summary of Cumulative Impact Assessment

Table 10.6-2 summarizes the CIA for the VECs identified as eligible for the CIA. The first column alongside each resource shows the potential impacts of the Yellowtail Project—annotated with a “C” and/or “O” to indicate whether the impact is associated with construction or operation stages—along with the associated impact significance ratings and risk ratings from Chapters 6 through 9. The table also indicates in the second row which stages of the Other Projects overlap with those of the Yellowtail Project. In lieu of discussing Special Status Species as a single resource, separate discussions are provided for all taxon-specific resources that have a special status species with potential occurrence in Guyana (i.e., Marine Fish, Marine Turtles, Marine Mammals, and Seabirds).

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Table 10.6-2: Summary of Cumulative Impact Assessment

VEC	Potential Impacts from Yellowtail Development Project	Other EEPGL Oil and Gas Exploration and Development Projects [a]	Fiber Optic Cable Project	Guyana Office Complex Project	Gas to Energy Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture Project	Hope Wind Farm	New Shorebase and Port Facilities	External Drivers	Cumulative Impact	Priority Ranking
Overlap?	---	Yes (C,O)	Yes (O)	Yes (O)	Yes (C,O)	TBD (C,O)?	TBD (C,O)?	Yes (O)	Yes (C,O)?	Yes	---	---
Air Quality, Climate, and Climate Change	Potential impacts include increased concentrations of criteria pollutant emissions from offshore sources, potentially resulting in health impacts to onshore receptors (C,O) (**Negligible**); and increased GHG emissions (C—**Negligible**, O—**Moderate**).	Similar types of impacts to those of the Project, with development projects each contributing similar scales of criteria pollutant and GHG emissions once they become operational. Based on cumulative air dispersion modeling, combined air quality impacts would still be considered Negligible based on percentage of WHO thresholds for maximum onshore concentrations. The Project and Other EEPGL Projects would cumulatively result in a roughly 165 percent increase (at peak year during the Project) in overall GHG emissions at a country level above 2004 levels (net removals would decrease approximately 14 percent).	Not expected to contribute to cumulative impacts, as primary emissions will be during construction, which does not overlap with Project.	Not expected to contribute to cumulative impacts, as primary emissions will be during construction, which does not overlap with Project.	Potential to contribute to cumulative impacts - depending on final design of GTE Project and associated power plant (not yet finalized), as this project and/or associated power plant will likely have significant emissions sources and operations are expected to overlap with Project.	Not expected to contribute to cumulative impacts, as primary emissions will be associated with construction and are not expected to be significant.	Not expected to contribute to cumulative impacts, as primary emissions will be associated with construction and are not expected to be significant.	Not expected to contribute to cumulative impacts, as primary emissions will be associated with construction and are not expected to be significant.	Potential to contribute to cumulative impacts - depending on final design and nature of emissions sources.	External drivers not expected to contribute to air quality cumulative impacts. Projected global climate change consequences would be expected to contribute incrementally.	The Project, Other EEPGL Projects, the GTE Project (and/or associated power plant), and possibly the new shorebase and port facilities would contribute to air quality impacts. For those activities where there are sufficient data to indicate emission levels (i.e., Other EEPGL Oil and Gas Projects), modeling indicates that cumulative impacts would not result in a higher significance level relative to a Project-only scenario. Embedded controls and mitigation measures proposed for the Project are therefore considered to be sufficient to address potential impacts on air quality from the range of activities considered. Therefore, no additional recommended actions are identified to mitigate potential cumulative impacts on air quality. The Project, Other EEPGL Projects, the GTE Project (and/or associated power plant), and possibly the new shorebase and port facilities would contribute to cumulative climate impacts, as would the global climate change external driver. It is therefore recommended that EEPGL consider measures in addition to the embedded controls and mitigation measures already adopted for the Project.	**Low (Air Quality)** **Medium (Climate)**
Marine Water Quality	Potential impacts include increased TSS concentrations in the water column from drilling (C - **Minor**) and changes in water quality and temperature from liquid effluent discharges (O - **Negligible**).	Similar types of impacts to those of the Project, with development projects each contributing similar drilling impacts during drilling stage, and similar effluent discharge impacts to those of the Project once they become operational. Based on cumulative water quality modeling, individual plumes from FPSOs/drill ships would not be expected to overlap, indicating limited potential for Other EEPGL Oil And Gas Projects to contribute to cumulative impacts.	Not expected to contribute to cumulative impacts, as discharges will be during construction, which does not overlap with Project.	No potential impacts anticipated.	Temporary increases in TSS concentrations during pipeline installation, and discharges to marine waters from hydrotesting of pipeline segments would be short-term in nature and likely would not overlap geographically with impacts from the Project, indicating limited potential to contribute to cumulative impacts.	Not expected to contribute to cumulative impacts, as discharges would not overlap geographically with impacts from the Project.	Potential impacts would not overlap geographically with impacts from the Project.	No potential impacts anticipated.	No potential impacts anticipated.	After severe flooding events, rivers might carry debris from inland areas, including agricultural fields, which could temporarily affect marine water quality in coastal areas. But these impacts would not be expected to overlap significantly with areas that would be impacted by Project discharges.	Impacts from non-Project activities are not expected to overlap (temporally and/or spatially) with those of the Project. Embedded controls and mitigation measures proposed for the Project are therefore considered to be sufficient to address potential impacts on the VEC from the range of activities considered. Therefore, no additional recommended actions are identified to mitigate potential cumulative impacts on the VEC.	**Low**

VEC	Potential Impacts from Yellowtail Development Project	Other EEPGL Oil and Gas Exploration and Development Projects [a]	Fiber Optic Cable Project	Guyana Office Complex Project	Gas to Energy Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture Project	Hope Wind Farm	New Shorebase and Port Facilities	External Drivers	Cumulative Impact	Priority Ranking
Seabirds (Special Status Species)	Potential impacts include direct mortality or injury from attraction to offshore Project facilities (C - **Negligible**, O – **Minor**), light and sound disturbance from Project activities (C - **Negligible**, O – **Minor**), and removal of FPSO as a resting place or attractant of prey (O – **Negligible**). Potential benefits include the use of major vessels as a resting place or attractant of prey (O – **Positive**).	Similar types of impacts to those of the Project, with development projects each contributing similar impacts during their drilling and operation stages. Risk of attraction and disturbance with increasing number of drill ships and FPSOs operating, although sharing of support vessels will tend to reduce the incremental number of support vessels with each additional drill ship / FPSO.	Not expected to contribute to cumulative impacts, as relevant activities will be during construction, which does not overlap with Project.	No potential impacts anticipated.	Potential impacts will be similar to those of the Project with respect to potential attraction and disturbance and distribution during burial of offshore pipeline, but impacts will only occur during construction, and relatively far from the Project, so potential to contribute to cumulative impacts is low.	No potential impacts anticipated.	No potential impacts anticipated.	Potential impacts to migratory shorebirds will be similar to those of the Project with respect to potential attraction and resultant mortality or injury from collisions with wind turbines and disturbance during construction and operation, although the two special status seabirds are unlikely to be present in the area near the wind turbines.	Potential impacts will be similar to those of the Project with respect to potential light and sound disturbance during nearshore construction, but impacts will only occur during construction, and far from the same impacts from the Project, so potential to contribute to cumulative impacts is low.	Projected rising temperatures associated with longer-term global climate change could potentially affect some seabird species' distribution ranges.	The Project, Other EEPGL Projects, the GTE Project, the Hope Wind Farm, and the New Shorebase and Port Facilities could have potential negative impacts on seabird special status species. The Project embedded controls would mitigate its potential impacts to the extent reasonably practicable. Longer-term global climate change could also potentially negatively affect this VEC. However, the Project is not expected to have an incremental contribution to the negative effects. Therefore, no additional actions from EEPGL are required to mitigate potential adverse cumulative impacts on the VEC beyond the proposed Project embedded controls and mitigation measures.	**Low**
Marine Mammals	Potential impacts include exposure to permitted discharges (O – **Negligible**), acoustic injury from underwater sound exposure (C - **Negligible**), and underwater sound disturbance leading to deviation from the area (C - **Moderate**, O - **Minor**). Potential risks include vessel strikes (an unplanned event) (C,O) (**Moderate**).	Similar types of impacts to those of the Project, with development projects each contributing similar drilling impacts during the drilling stage, and similar effluent discharge impacts to those of the Project once they become operational. Risk from potential vessel strikes with increasing number of drill ships and FPSOs operating, although sharing of support vessels will tend to reduce the incremental number of support vessels with each additional drill ship / FPSO.	Not expected to contribute to cumulative impacts, as relevant activities will be during construction, which does not overlap with Project.	No potential impacts anticipated.	Potential impacts include exposure to permitted discharges and underwater sound disturbance leading to deviation from the area during construction. Similarly, vessel strike risk will be present, but only during construction.	No potential impacts anticipated.	No potential impacts anticipated.	No potential impacts anticipated.	No potential impacts anticipated.	Projected rising temperatures (including sea temperatures) associated with longer-term global climate change could potentially affect some fish species distribution and, in consequence, alter the distribution of marine mammals that prey on them.	Balancing the conservation status of the more abundant marine mammal species known to be present in the Project AOI with that of the rarer species that could be present, the cumulative vessel movements from the Project and the Other EEPGL Projects will contribute to cumulative impacts from potential vessel strikes. Actions should be implemented by EEPGL in the medium term to mitigate potential adverse cumulative impacts on the VEC.	**Medium**
Marine Turtles (Special Status Species)	**Marine Turtles:** Potential impacts include disturbance from artificial lighting (O - **Negligible**), displacement from habitat due to disturbance from vessel activity (C,O) (**Negligible**), acoustic injury from sound exposure (C - **Negligible**), and exposure to permitted discharges (O - **Negligible**). Potential risks include vessel strikes (an unplanned event) (C,O) (**Moderate**, with **Unlikely** likelihood).	Similar types of impacts to those of the Project, with development projects each contributing similar impacts during drilling stage, and similar effluent discharge impacts to those of the Project once they become operational. Risk from potential vessel strikes with increasing number of drill ships and FPSOs operating, although sharing of support vessels will tend to reduce the incremental number of support vessels with each additional drill ship / FPSO.	Not expected to contribute to cumulative impacts, as relevant activities will be during construction, which does not overlap with Project.	No potential impacts anticipated.	Potential impacts include exposure to permitted discharges and underwater sound disturbance leading to deviation from the area during construction. Similarly, vessel strike risk will be present, but only during construction.	No potential impacts anticipated.	No potential impacts anticipated.	No potential impacts anticipated.	No potential impacts anticipated.	The large-scale commercial trawl fishery mainly targets seabob, yet unselective fishing gear such as bottom trawls can cause harm to other fisheries and to the marine environment by catching juvenile fish and turtles, damaging the seafloor, and leading to overfishing. Bottom trawl nets can also harm coral reefs, sharks, and marine turtles.	All five species of marine turtles found in the region have IUCN Red List categories ranging from VU to CR. However, the prevalence of marine turtles is relatively low (e.g., as compared to marine mammals) and turtle telemetry studies have shown that the chance of a turtle interacting with a Project vessel would be primarily limited to an instance where a turtle was crossing in front of the Demerara Harbour on its way to feeding grounds (relative for Green turtles) at the same time that a Project or Other Project vessel was passing in or out of the harbor. This is a very low likelihood event. On this basis, it is concluded that no additional actions from EEPGL are required to mitigate potential adverse	**Low**

VEC	Potential Impacts from Yellowtail Development Project	Other EEPGL Oil and Gas Exploration and Development Projects [a]	Fiber Optic Cable Project	Guyana Office Complex Project	Gas to Energy Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture Project	Hope Wind Farm	New Shorebase and Port Facilities	External Drivers	Cumulative Impact	Priority Ranking
											cumulative impacts on the VEC beyond the proposed Project embedded controls and mitigation measures.	
Marine Fish	Potential impacts include auditory impacts on fish (pelagic species) from vessel activity (C,O) (**Negligible**), disturbance from or attraction to offshore lighting that would affect pelagic species (O - **Negligible**), auditory impacts on demersal species from pile driving and VSP during drilling (C - **Negligible**), entrainment of pelagic species in water intakes (O - **Negligible**), and distribution and habitat changes from altered water quality for pelagic species (C,O) (**Negligible**) and demersal species (C – **Minor**, O - **Negligible**).	Similar types of impacts to those of the Project, with development projects each contributing to similar impacts during their drilling and operation stages. Based on cumulative water quality modeling, individual TSS plumes from drill ships (driving the Minor significance rating for the potential impact on demersal species during the drilling stage) would not be expected to overlap, indicating limited potential for Other EEPGL Oil and Gas Projects to contribute to cumulative impacts.	Not expected to contribute to cumulative impacts, as relevant activities will be during construction, which does not overlap with Project.	No potential impacts anticipated.	Potential impacts will be similar to those of the Project with respect to potential auditory disturbance and distribution and habitat changes from altered water quality during burial of offshore pipeline, but impacts will only occur during construction, and relatively far from the Project, so potential to contribute to cumulative impacts is low.	Potential impacts will be similar to those of the Project with respect to potential auditory disturbance and distribution and habitat changes from altered water quality during bridge construction, but impacts will only occur during construction, and far from the same impacts from the Project, so potential to contribute to cumulative impacts is low.	The main potential impacts from this project would likely be predation of fingerlings of various species of wild fish that will enter the offshore pens. This is not expected to contribute to cumulative impacts with the Project.	No potential impacts anticipated.	Potential impacts will be similar to those of the Project with respect to potential auditory disturbance and distribution and habitat changes from altered water quality during nearshore construction, but impacts will only occur during construction, and far from the same impacts from the Project, so potential to contribute to cumulative impacts is low.	The large-scale commercial trawl fishery mainly targets seabob, yet unselective fishing gear such as bottom trawls can cause harm to other fisheries and to the marine environment by catching juvenile fish and damaging the seafloor. Projected rising temperatures associated with longer-term global climate change could potentially affect some marine fish species' distribution ranges.	Impacts from non-Project activities are not expected to overlap (temporally and/or spatially) with those of the Project. External drivers such as commercial trawl fishing and longer-term global climate change could contribute to overall impacts on this VEC. However, the Project's impacts are not expected to contribute significantly to a cumulative impact. Embedded controls and mitigation measures proposed for the Project are therefore considered to be sufficient to address potential impacts on the VEC from the range of activities considered. Therefore, no additional recommended actions are identified to mitigate potential cumulative impacts on the VEC.	**Low**
Riverine Mammals	Potential impacts include behavioral changes or displacement as a result of increased vessel traffic within Georgetown Harbour (C,O) (**Minor**). Potential risks include vessel strikes (an unplanned event) (C,O) (**Minor**).	Similar types of impacts to those of the Project, with increasing potential for disturbance impacts and risks from potential vessel strikes with increasing number of drill ships and FPSOs operating, although sharing of support vessels will tend to reduce the incremental number of support vessels with each additional drill ship / FPSO.	Not expected to contribute to cumulative impacts, as relevant activities will be during construction, which does not overlap with Project.	No potential impacts anticipated.	Potential impacts include potential disturbance leading to deviation from nearshore areas during construction. Similarly, vessel strike risk will be present, but only during construction.	Potential impacts include potential disturbance during construction. Similarly, vessel strike risk will be present from construction vessels, but only during construction.	No potential impacts anticipated.	No potential impacts anticipated.	Potential impacts include disturbance during construction. Similarly, vessel strike risk will be present from construction vessels, but only during construction.	Projected rising temperatures (including sea temperatures) associated with longer-term global climate change could potentially affect the distribution of riverine mammals. Marine fisheries and subsistence fishing occur throughout Guyana's coastal waters, and their vessels and fishing activities could potentially further displace riverine mammal species that occur in the brackish/ intertidal waters of Georgetown Harbour.	Riverine mammals likely to occur within Georgetown Harbour and the nearshore portion of the marine vessel transit corridor are vulnerable to vessel collision and negative effects from disturbance of their habitats, such as changes in behavior and displacement. While the Project could contribute incrementally to increased risk of vessel strikes, the level of habituation of manatees in Georgetown Harbour reduces the level of overall risk. No additional actions are recommended for EEPGL to mitigate potential adverse cumulative impacts on this VEC beyond the currently proposed Project embedded controls and mitigation measures.	**Low**

VEC	Potential Impacts from Yellowtail Development Project	Other EEPGL Oil and Gas Exploration and Development Projects [a]	Fiber Optic Cable Project	Guyana Office Complex Project	Gas to Energy Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture Project	Hope Wind Farm	New Shorebase and Port Facilities	External Drivers	Cumulative Impact	Priority Ranking
Ecological Balance and Ecosystems	Potential impacts include introduction of invasive species via ballast water discharges (O) (**Minor**), changes in marine nutrient cycle, resulting in localized and temporary changes in phytoplankton species distribution (C,O) (**Negligible**), and impacts on gene flow (C,O) (**Negligible**).	Similar types of impacts to those of the Project, with increasing potential for biodiversity impacts (through potential invasive species introduction in ballast water exchanges) with increasing number of FPSOs operating.	No potential impacts anticipated.	No potential impacts anticipated.	Potential (construction stage only) impacts are similar to those of the Project, but the scale of potential biodiversity impacts is much lower due to the lack of ongoing ballast water exchanges, leading to a low potential to contribute to cumulative impacts.	No potential impacts anticipated.	This project will have the potential for impacts on this VEC, but these impacts are not anticipated to combine with the Project's potential impacts to contribute to cumulative impacts.	No potential impacts anticipated.	No potential impacts anticipated.	Unselective fishing gear such as bottom trawls can cause harm to other fisheries and to the marine environment by catching juvenile fish or turtles. These impacts would have a negative effect on the ecological balance of the coastal-marine ecosystem. Longer-term global climate-change-driven increases in the global mean temperatures could have a significant impact on ecosystems and ecological balance. For example, some ecosystems may become more vulnerable to invasive species.	The Project, Other EEPGL Projects, and external drivers would contribute to potential negative impacts on this VEC. However, the embedded controls proposed by the Project would be expected to appropriately limit the Project's contribution. Therefore, no additional actions from EEPGL are recommended to mitigate potential adverse cumulative impacts on the VEC.	**Low**
Economic Conditions	Potential impacts include adverse impacts on the Guyanese population (in particular Georgetown population) with the potential for increased cost of living and the potential for competition with other local businesses for qualified workers (C,O) (**Negligible** for general population, **Minor** for lower income subpopulation). Potential benefits include increased government revenues and increased employment, increased local business activity (C,O - **Positive**). The overall potential impact on socioeconomic conditions is expected to be (net) **Positive**.	Similar adverse and beneficial impacts as those of the Project, with an overall net positive impact from increased government revenues and employment benefiting the local economy.	No potential impacts anticipated.	No potential impacts anticipated.	Potential benefits include reduced cost of energy and increased reliability and associated indirect economic benefits, which would be additive to the net positive economic benefits from the Project.	No potential impacts anticipated.	No potential impacts anticipated.	No potential impacts anticipated.	No potential impacts anticipated.	Projected changes in rainfall patterns, sea-level rise, and increased temperatures associated with longer-term global climate change pose threats to the Guyanese population and the economy, potentially causing supply/demand disruptions and increased costs.	The Project, Other EEPGL Projects, and external drivers would contribute to potential adverse impacts on this VEC, with the most vulnerable portion being the lower income subpopulation in and near Georgetown. However, the net positive economic impact of the Project and Other EEPGL Projects, combined with the beneficial effects of the GTE project, would results in an overall net positive benefit due to increased government revenues, employment, business opportunity, and reduced energy cost. Therefore, no additional actions from EEPGL are recommended to mitigate potential adverse cumulative impacts on the VEC.	**Low**

VEC	Potential Impacts from Yellowtail Development Project	Other EEPGL Oil and Gas Exploration and Development Projects [a]	Fiber Optic Cable Project	Guyana Office Complex Project	Gas to Energy Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture Project	Hope Wind Farm	New Shorebase and Port Facilities	External Drivers	Cumulative Impact	Priority Ranking
Employment and Livelihoods	Potential adverse impacts include impacts on fishing livelihoods as a result of marine safety exclusion zones within the PDA for commercial fishing operations (C,O) (**Negligible**) and interference with subsistence fishing (C,O) (**Minor**). Potential benefits include increased employment, local business activity, and household income (O - **Positive**).	Similar types of impacts to those of the Project, with development projects each contributing similar impacts during drilling and operational stages, and with presence of exclusion zones increasing with increasing number of drill ships and FPSOs operating. However, sharing support vessels will tend to reduce the incremental number of support vessels with each additional drill ship / FPSO.	Not expected to contribute to cumulative impacts, as relevant activities will be during construction, which does not overlap with Project.	No potential impacts anticipated.	Similar types of impacts to those of the Project, but only as a result of marine safety exclusion zones during offshore pipeline construction. Potential benefits include increased employment, local business activity, and household income (O - **Positive**).	No potential impacts anticipated.	No potential impacts anticipated.	No potential impacts anticipated.	No potential impacts anticipated.	Unselective use of fishing gear such as bottom trawls can cause harm to other fisheries. Projected changes in rainfall patterns, sea-level rise, and increased temperatures associated with longer-term global climate change pose threats to the Guyanese population and its livelihoods during the Project life cycle, including onshore and offshore livelihoods.	The Project, Other EEPGL Projects, and external drivers would contribute to potential negative impacts on this VEC, the most vulnerable sub-category of which would be artisanal fisherfolk. However, the embedded controls and mitigation measures proposed for the Project would be expected to appropriately limit the Project's contribution. Therefore, no additional actions from EEPGL are recommended to mitigate potential adverse cumulative impacts on the VEC.	**Low**
Community Health and Wellbeing	Potential impacts include increased risk of communicable disease transmission (C,O) (**Negligible**), impacts on public safety (C,O) (**Negligible**), public anxiety over oil and gas sector risks for communities in Georgetown (O - **Negligible**) and outside Georgetown (O - **Minor**), and reduced access to emergency and health services (C,O) (**Negligible**).	Similar types of impacts to those of the Project, with increasing activities potentially leading to increased potential for the various types of impacts. With respect to potential for public anxiety, this would be balanced against what would be expected to be a growing familiarity of the population with oil and gas operations.	No potential impacts anticipated.	No potential impacts anticipated.	Similar types of impacts to those of the Project, with potential public anxiety limited to that of the area near the NGL Plant and associated onshore pipeline (as opposed to broader coastal communities).	No potential impacts anticipated.	No potential impacts anticipated.	No potential impacts anticipated.	No potential impacts anticipated.	Flooding can potentially increase the transmission of communicable diseases, such as water-borne diseases (e.g., typhoid fever, cholera) and can provide conditions conducive to mosquito breeding, increasing the incidence of mosquito-borne diseases (e.g., malaria, dengue).	The Project could contribute along with Other EEPGL Projects, and the GTE Project to impacts on this VEC. However, the embedded controls and mitigation measures proposed for the Project would be expected to appropriately limit the Project's contribution. Therefore, no additional actions from EEPGL are recommended to mitigate potential adverse cumulative impacts on the VEC.	**Low**
Marine Use and Transportation	Potential impacts include increased vessel traffic between Georgetown Harbour and the PDA and reduced availability of ocean surface areas for commercial fishing (C,O) (**Negligible**), and potentially leading to interference with commercial cargo (C,O) (**Negligible**), commercial fishing (C,O) (**Minor**), and subsistence fishing vessels (C,O) (**Minor).**	Similar types of impacts to those of the Project, with development projects each contributing similar impacts during drilling and operational stages, and with presence of exclusion zones increasing with the increasing number of drill ships and FPSOs operating. However, sharing of support vessels will tend to reduce the incremental number of support vessels with each additional drill ship / FPSO.	Not expected to contribute to cumulative impacts, as relevant activities will be during construction, which does not overlap with Project.	No potential impacts anticipated.	Similar types of impacts to those of the Project, but only as a result of marine safety exclusion zones and construction vessel movements during offshore pipeline construction.	Similar types of impacts to those of the Project, but only as a result of marine safety exclusion zones and construction vessel movements during bridge construction.	Similar types of impacts to those of the Project, inclusive of permanent marine safety exclusion zones and ongoing operational support vessel movements.	No potential impacts anticipated.	Similar types of impacts to those of the Project, but only as a result of marine safety exclusion zones and construction vessel movements during nearshore construction.	Potential increases in commercial fishing vessels could contribute to local marine traffic in the region.	The Project, Other EEPGL Projects, the CMI Project, and external drivers would contribute to potential negative impacts on this VEC, the most vulnerable sub-category of which would be artisanal fisherfolk. However, the embedded controls and mitigation measures proposed for the Project would be expected to appropriately limit the Project's contribution. Therefore, no additional actions from EEPGL are recommended to mitigate potential adverse cumulative impacts on the VEC.	**Low**
Social Infrastructure and Services	Potential impacts include Increased demand for use of lodging, leading to reduced availability and/or increased cost (C – **Minor**, O - **Negligible**),	Similar types of impacts to those of the Project, with development projects each contributing similar impacts during drilling and operational stages, and with pressures on	No potential impacts anticipated.	The project could contribute to cumulative impacts on traffic congestion for road segments	Similar types of impacts to those of the Project, primarily during construction stage when peak workforce will be	Similar types of impacts to those of the Project, primarily during construction stage when peak	No potential impacts anticipated.	Not expected to contribute to cumulative impacts, as relevant activities will be during	Similar types of impacts to those of the Project, primarily during construction stage when peak workforce will be	Guyana is vulnerable to increased flooding from longer-term global climate change impacts due to the low-lying coastal areas,	The Project could contribute along with Other EEPGL Projects, the Guyana Office Campus, the GTE Project, and the proposed shorebase/port projects to impacts on this VEC. This could include construction-stage housing/lodging	**Low**

VEC	Potential Impacts from Yellowtail Development Project	Other EEPGL Oil and Gas Exploration and Development Projects [a]	Fiber Optic Cable Project	Guyana Office Complex Project	Gas to Energy Project	Replacement of Demerara Harbour Bridge	Caribbean Mariculture Project	Hope Wind Farm	New Shorebase and Port Facilities	External Drivers	Cumulative Impact	Priority Ranking
	decreased availability/ increased cost of housing and utilities (C – **Minor**, O - **Negligible**), increase in traffic congestion (C,O) (**Minor**), and increase in heliport congestion (C,O) (**Negligible**).	housing/lodging and increased traffic congestion all increasing with the increasing number of drill ships and FPSOs operating.		near and leading to the Campus.	present. The project could contribute to some level of impact on traffic during operations, but the limited workforce during this stage will limit this contribution.	workforce will be present.		construction, which does not overlap with Project.	present. The projects could contribute to impacts on traffic during operations, but there is currently not sufficient information on the projects to assess the level of impact.	many below mean sea level and with a high percentage of the population and critical infrastructure located along the coast.	pressures and construction and operations stage traffic congestion impacts. However, the embedded controls and mitigation measures proposed for the Project would be expected to appropriately limit the Project's contribution. Therefore, no additional actions from EEPGL are recommended to mitigate potential adverse cumulative impacts on the VEC.	
Waste Management Infrastructure Capacity	During all Project stages, a key potential impact from Project-related waste generation would be: • Contribution to overburdening of existing capacity of hazardous waste treatment facilities in Georgetown (**Negligible**). • Contribution to overburdening of local landfill existing capacity (**Minor**).	Similar types of impacts to those of the Project, with development projects each contributing similar impacts during drilling and operational stages, and waste volumes increasing with increasing number of drill ships and FPSOs operating. However, waste volumes are driven by drilling-stage contributions, so overall demands will decrease as drilling for development projects is reduced/completed.	Not expected to contribute to cumulative impacts, as relevant activities will be during construction, which does not overlap with Project.	The Campus will contribute to an increased burden on waste management during construction and throughout operations.	The GTE Project will contribute to an increased burden on waste management during construction and throughout operations.	This project will contribute to an increased burden on waste management during construction.	No potential impacts anticipated.	This project will contribute to an increased burden on waste management during construction.	This project will contribute to an increased burden on waste management during construction and throughout operations.	The Consultants do not foresee impacts from the external drivers on this VEC.	The Project and many of the Other Projects (EEPGL and non-EEPGL) could incrementally contribute to the effects on this VEC, potentially accelerating the degree to which capacity constraints will manifest. This is most likely to be a challenge in relation to non-hazardous waste management (landfill) capacity. The Project has implemented embedded controls and adopted mitigation measures to facilitate continued viable access to waste management infrastructure of a sufficient quality and with sufficient capacity to serve its needs. Assuming implementation of these mitigation measures and embedded controls, and progress made to date with landfill expansion, the concerns regarding landfill capacity are considered to be addressed for the Project. However, based on the fact that capacity expansions for the HBL and/or construction of additional landfill sites in Georgetown are not under EEPGL's control, and the uncertainty associated with other growing demands on landfill capacity, actions should be implemented by EEPGL in the medium term to mitigate potential adverse cumulative impacts on the VEC.	**Medium**

CR = Critically Endangered; IUCN = International Union for Conservation of Nature; VSP = Vertical Seismic Profile; VU = Vulnerable
[a] Ongoing drilling and exploration – EEPGL, Repsol, Tullow, CGX; EEPGL Liza Phase 1 Liza Phase 2, and Payara; EEPGL FPSO #5 and FPSO #6

10.7. CUMULATIVE IMPACTS MANAGEMENT FRAMEWORK

Cumulative impacts often result from the successive, incremental, and/or combined impacts of multiple developments. Accordingly, responsibility for their prevention and management is shared among the various contributing developments. It is usually beyond the capability of any one party to implement all of the measures needed to reduce or eliminate cumulative impacts. In the following sections, recommendations are provided at the Project level, the EEPGL level (as EEPGL is the operator for several of the Other Projects assessed in the CIA), and the regional level.

10.7.1. Project Level

Effective application of the mitigation hierarchy (avoid, reduce, remedy) to manage individual contributions of cumulative impacts is recommended as good international oilfield practice (IFC 2013). EEPGL has incorporated a number of embedded controls (see Section 2.14, Embedded Controls, for a detailed list and description), which are physical or procedural controls that are planned as part of the Project design. These are considered from the very start of the impact assessment process as part of the Project, and are factored into the pre-mitigation impact significance ratings. In addition, a number of mitigation measures (see Chapters 6, 7, 8, and 13) have been proposed to address potential impacts from the Project. The EIA also includes an Environmental and Socioeconomic Management Plan, which summarizes the embedded controls and mitigation and monitoring measures by VEC.

At the Project level, the above-referenced measures are considered sufficient to address the contributions of the Project to cumulative impacts.

10.7.2. EEPGL Level

Three medium priority cumulative impacts on VECs (i.e., for climate, marine mammals, and waste management infrastructure capacity) were identified, suggesting that additional consideration should be given in the medium-term to address potential cumulative impacts on these VECs. The medium priority ranking on marine mammals derives primarily from the potential cumulative impacts that could arise from additional vessel movements from simultaneous oil exploration and production operations (leading to the potential for an increased risk from vessel strikes). Accordingly, it is recommended that EEPGL, when designing and undertaking additional projects/activities, ensure that the same level of potential impact management (i.e., as in Yellowtail) be implemented (e.g., embedded controls associated with minimization of the risk of marine mammal vessel strikes). In addition, with the intention of minimizing the potential interactions between effects of multiple projects, it is recommended that EEPGL take measures, where feasible and practicable, to share logistical resources between development projects—to reduce the number of additional vessel movements associated with additional projects. This approach would be expected to be sufficient to address contributions of the Project and Other EEPGL Projects to cumulative impacts on marine mammals.

Regarding climate, EEPGL has developed a flare minimization plan (see Section 6.1, Air Quality, Climate, and Climate Change), and has committed to continue measuring and reporting its GHG contributions to national emissions. It is recommended that EEPGL continue to assess measures that can be taken to minimize GHG emissions during each project's production operations stage, and ensure that a Best Available Technology assessment process (i.e., as conducted for the Yellowtail Project) be undertaken to assess the feasible and appropriate embedded controls and mitigation measures that can be implemented to reduce GHG emissions.

In the case of waste management infrastructure capacity, the mitigation measures already initiated by EEPGL represent appropriate efforts to manage the cumulative impacts on this VEC. These include the following:

- As warranted based on anticipated future EEPGL hazardous waste generation trends and trends in non-EEPGL hazardous waste generation, continue enabling the expansion of existing local waste management capacity for hazardous wastes and explore use of new local hazardous waste treatment facilities, or identify suitable alternative solutions.
- Continue monitoring of plans for further expansion of the HBL and/or (if approved by the EPA) construction of additional landfill sites in other locations (as decided by the government), or identify suitable alternative (interim) local solutions for non-hazardous waste management.

10.7.3. Regional Level

The CIA did not identify any high priority cumulative impacts on VECs. Therefore, the Consultants do not deem necessary the development and implementation of a multi-stakeholder collaborative management framework. However, as cumulative impacts could vary in the future, with the addition of other projects or external drivers, it is recommended that EEPGL consider participation, to the extent feasible and practicable, in working groups and/or industry organizations aimed at addressing management of potential impacts on regional resources to which EEPGL's projects could incrementally contribute with respect to cumulative impacts.

11. ENVIRONMENTAL AND SOCIOECONOMIC MANAGEMENT PLAN FRAMEWORK

11.1. INTRODUCTION

This chapter provides a framework for the Project Environmental and Socioeconomic Management Plan (ESMP). The ESMP is the document that describes the measures EEPGL will implement to manage the Project's potential environmental and socioeconomic risks and reduce impacts on the environment and communities. The scope of this chapter includes the following:

- Overview of the policy framework underpinning the ESMP;
- Description of the ESMP structure;
- Description of the general ESMP guiding principles;
- Description of the general content of the management plans comprising the ESMP; and
- Description of how updates to the ESMP will be managed.

The Terms and Scope for this EIA require an ESMP, consisting of several affiliate-level, environmental media-specific, or contingency-focused management plans, to be submitted concurrently with the EIA. The individual management plans that comprise the ESMP have been prepared consistent with the framework described herein. EEPGL will update the ESMP and its constituent plans to address the final conditions from the environmental authorization upon approval of the Project by the EPA.

11.2. REGULATORY AND POLICY FRAMEWORK

The Project is and will be subject to various regulatory requirements as described in Chapter 3, Administrative Framework, the resource-specific laws and any commitments described in each resource-specific discussion, the conditions established by the EPA upon issuance of the environmental authorization, and the conditions of the Petroleum Production Licence, once issued. Other government agencies also have relevant regulatory authority over aspects of the Project, including, but not limited to, the Ministry of Agriculture's Fisheries Department, Guyana Revenue Authority, Civil Defence Commission, Guyana Geology and Mines Commission, and Maritime Administration Department.

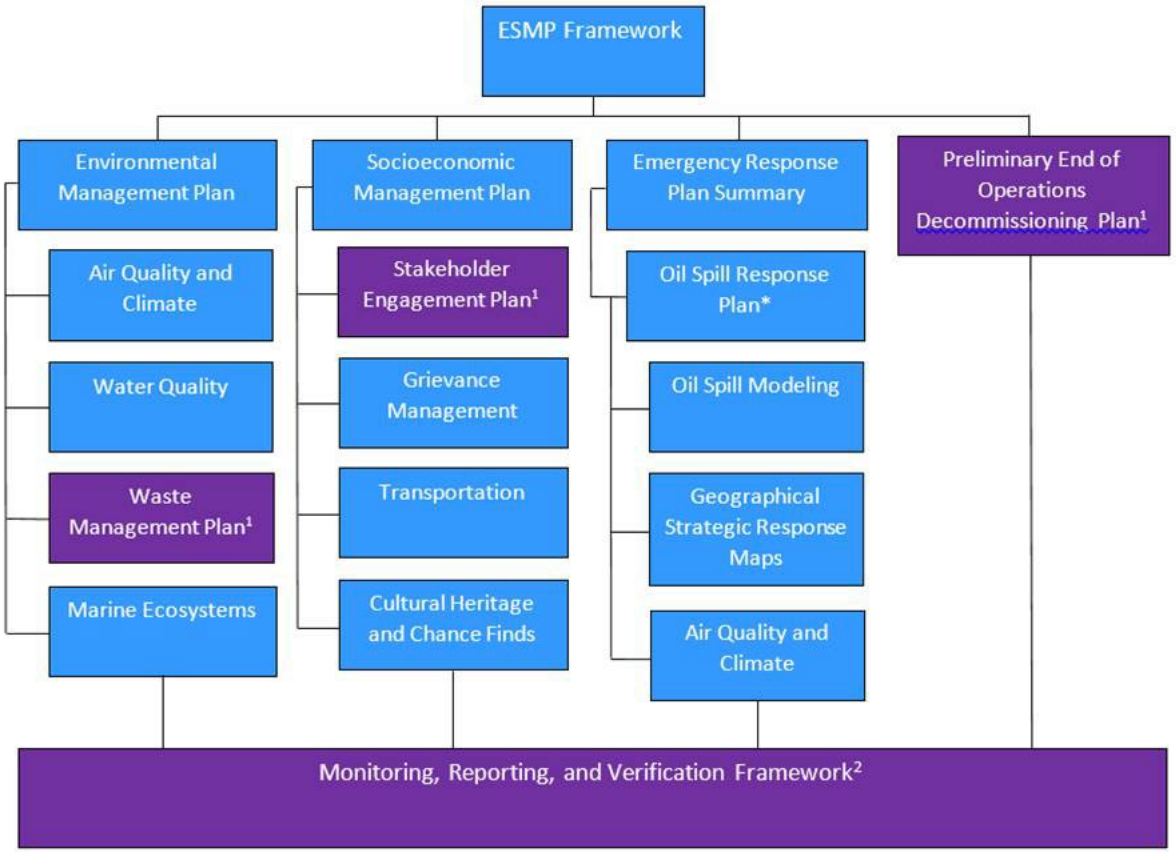
EEPGL is committed to ensuring its compliance with the laws and regulations of Guyana, and conducting business in a manner that is compatible with the environmental and economic needs of the communities in which it operates, and that protects the safety, security, and health of its employees, those involved with its operations, its customers, and the public. These commitments are documented in its Safety, Security, Health, Environmental, and Product Safety policies. These policies are put into practice through a disciplined management framework called the Operations Integrity Management System, which is further described in Section 3.5, Management Plans.

11.3. ESMP STRUCTURE

Figure 11.3-1 depicts the overall structure of the Project ESMP. The specific management plans included in the ESMP are organized into five categories:

- Environmental Management
- Socioeconomic Management
- Environmental and Socioeconomic Monitoring
- Emergency Response Plan Summary, which includes oil spill response
- Preliminary End of Operations Decommissioning[1]

Each of these categories includes one or more specific management plans that are included within the ESMP unless otherwise noted, as shown in Figure 11.3-1.



[1] Due to the size and/or complexity of these documents, these are stand-alone plans, and are provided as an appendix to the ESMP or as a separate attachment to the regulatory submittal for the Yellowtail Development Project (e.g., Oil Spill Response Plan).
[2] The Monitoring, Reporting, and Verification Framework is currently under development by EEPGL in accordance with the Environmental Permit issued for the Payara Development Project.

Figure 11.3-1: ESMP Structure

[1] In alignment with the EPA's Initial Closure and Reclamation Plan

11.4. GENERAL ESMP GUIDING PRINCIPLES

EEPGL developed the overall ESMP, and each of the specific management plans it contains, consistent with the following guiding principles:

- Covers all Project stages (i.e., there are not separate management plans for each Project stage, except for a Preliminary End of Operations Decommissioning Plan);
- Contains a level of detail that is fit for purpose and varies among the individual management plans;
- Represents a “living document” that will be revised or amended as the Project progresses in response to changing circumstances, lessons learned, or other appropriate reasons;
- Develops some of the management plans as countrywide plans (e.g., Oil Spill Response Plan, Comprehensive Waste Management Plan, Stakeholder Engagement Plan), with asset-level details contained in an attachment as required, with the rest of the management plans (at this time) remaining asset-specific; and
- Reflects all regulatory commitments and obligations, including those from the EIA, supporting plans, and environmental authorizations.

11.5. MANAGEMENT PLAN CONTENTS

The ESMP contains an introduction and scope as well as a summary of the applicable regulations, standards, and guidelines. The environmental and socioeconomic management plans are fit for purpose, and therefore vary to some extent in content, but contain resource-specific management measures that include proposed mitigation measures developed from the impact assessment as well as embedded controls (see Chapter 13, Recommendations). The plans also include the following information for each measure:

- The source of potential impact;
- The affected receptor;
- The specific Project component(s) for which the control/measure will be implemented (e.g., Floating Production, Storage, and Offloading vessel, support vessels, shorebases, etc.) and/or the specific stage or stages of the Project during which each measure will be implemented (e.g., drilling, installation, production operations);
- A description of the management measure; and
- Monitoring, recordkeeping, and reporting requirements, where applicable.

11.6. MANAGEMENT OF CHANGE

During Project implementation, changes may be required to address unanticipated conditions or situations. Managing change is an integral part of the Operations Integrity Management System, as described in Chapter 3 of the EIA. Risk assessments, audits, inspections, and/or observations may identify the need for amendments to the ESMP. In these cases, the ESMP will be updated to reflect the change. In addition, the ESMP will be updated when applicable environmental laws, regulations, standards, and/or company processes, systems, and/or technologies that are being applied to the Project change. EEPGL will notify the EPA of any significant updates to the ESMP and will provide an updated version of the document for their records and use. The ESMP is also envisioned to be a living document that will be updated to reflect continuous learning and improvements, and will be shared with the Government of Guyana.

12. CONCLUSIONS AND SUMMARY OF IMPACTS

This section summarizes the potential environmental and socioeconomic impacts resulting from planned Project activities and the risks from potential unplanned events on resources and receptors, as well the Project's potential contributions to cumulative impacts on Valued Environmental and Social Components.

12.1. PLANNED PROJECT ACTIVITIES

The planned Project activities are predicted to have **Negligible** to **Moderate** impacts on physical resources (i.e., air quality, climate, and climate change; marine geology and sediments; marine water quality), no impacts on coastal biological resources, **Negligible** to **Moderate** impacts on marine biological resources, and **Negligible** to **Minor** impacts on socioeconomic resources—with largely positive impacts on socioeconomic conditions. These predictions result from the fact that the bulk of the Project will occur approximately 203 kilometers (126 miles) northeast of the coastline of Georgetown, and that the Project will:

- Re-inject associated natural gas (the portion that is not used as fuel on the Floating Production, Storage, and Offloading [FPSO] vessel, excluding *de minimis* sources not captured by the Vapor Recovery Unit) back into the reservoirs;
- Treat all process and effluent streams as required prior to discharge to the sea;
- Avoid, reduce, and reuse/recycle wastes preferentially prior to disposal in accordance with the waste management hierarchy, and provide for adequate onshore waste management equipment and facilities for the proper management of waste in accordance with local regulation and good international oil field practice;
- Have a very small physical footprint (e.g., installation of infrastructure will only physically disturb up to 0.66 square kilometer [0.26 square mile] of benthic habitat);
- Use Marine Mammal Observers and "soft starts" during vertical seismic profile to reduce the potential for auditory injury or disturbance to marine animals; and
- Minimize the frequency and duration non-routine flaring through the design and use of expanded installed spare gas compression equipment capacity as part of a comprehensive flare minimization plan.

The Project will generate benefits for the citizens of Guyana through revenue sharing with the Government of Guyana, a minor increase in employment, and in-country Project purchasing of goods and services from Guyanese businesses. In summary, planned Project activities, including these and other management measures, are expected to pose only minor risks to the environmental and socioeconomic resources of Guyana, while potentially offering significant economic benefits to the residents of Guyana.

12.2. UNPLANNED EVENTS

Unplanned events, such as a potential oil spill, are considered unlikely to occur due to the extensive preventive measures employed by EEPGL; nevertheless, an oil spill is considered possible. The types of resources that would potentially be impacted and the extent of the impacts on those resources would depend on the volume and duration of the release, as well as the time of year, but impacts would tend to be most significant for a loss-of-well-control event with loss of containment during the drilling stage. EEPGL has conducted oil spill modeling to evaluate the range of possible spill trajectories and rates of travel. The location of the Project 203 kilometers (126 miles) offshore, prevailing northwest currents, the nature of the Yellowtail and Redtail fields' crude oil, and the region's warm waters would all help reduce the severity of a spill. Accounting for these factors, modeling of an unmitigated subsea release of crude oil from a loss-of-well-control event indicates a 5 to 40 percent probability of oil reaching the Guyana coast, without taking into consideration the effectiveness of any oil spill response, and in the unlikely event that a spill were even to occur.

Although the probability of an oil spill reaching the Guyana coast is very small, a subsea release of crude oil from a loss-of-well-control event at a Project well would likely impact any marine resources near the well, which could include marine turtles and certain marine mammals (especially baleen whales) that may transit or inhabit the area impacted by the spill, as well as marine water quality. Other physical and biological resources such as air quality, seabirds, marine fish, and marine benthos could also be impacted, although likely to a lesser extent because the duration of acute impacts would not be long and the impacts are reversible.

A coastal fuel spill (i.e., of marine diesel) could occur as a result of another unplanned event (e.g., Project vessel collision or grounding, release during bunkering of a supply vessel). Depending on the scale of a coastal fuel spill, the types of physical or biological resources that could be impacted would be generally similar to those potentially impacted by a marine oil spill.

Either a marine oil spill or a coastal fuel spill could potentially impact Guyanese fisherfolk if commercial fish and shrimp resources were impacted. The magnitude of this impact would depend on the volume and duration of the release as well as the time of year at which the release were to occur (e.g., whether a spill would coincide with the time of year when these resources are more abundant in the Project Development Area). Effective implementation of EEPGL's Oil Spill Response Plan would reduce this risk by reducing the ocean surface area impacted by a spill and thereby reducing the exposure of these resources to oil.

Additional unplanned events, which are also considered unlikely to occur due to the preventive measures employed by EEPGL, could include collisions between Project vessels and non-Project vessels; Project vessel strikes of marine mammals, marine turtles, riverine mammals, or rafting seabirds; collisions between Project vehicles and non-Project vehicles; and a release of untreated wastewater from the FPSO. The impact extent from these types of events would depend on the exact nature of the event. However, in addition to reducing the likelihood of occurrence, the embedded controls that EEPGL will put in place if such an event were to occur (e.g., training of vessel operators to recognize and avoid marine mammals, riverine mammals, and marine turtles; adherence to international and local marine navigation procedures;

adherence to Road Safety Management Procedure) would also serve to reduce the likely extent of impact.

12.3. CUMULATIVE IMPACTS

The Project's expected contribution to potential cumulative impacts will be limited by its distance offshore, by the distance between the Project and other EEPGL projects/activities, and by the small number of non-EEPGL projects or activities either operating or currently planned to be operating offshore of Guyana. Other EEPGL offshore Guyana oil and gas exploration and development activities include the Liza Phase 1 Development Project, which is currently operational; the approved Liza Phase 2 Project, which is expected to become operational in early 2022; the Payara Development Project; continued exploration drilling; future planned offshore development projects (assumed for the purpose of this assessment to also be in the Stabroek Block); and the proposed Gas to Energy Project, which would transport gas by pipeline from the Liza Project Development Area to shore to remove natural gas liquids and provide gas for a possible natural gas-fired power plant. Potential future offshore Guyana oil and gas exploration by other developers could also potentially contribute to cumulative effects. Additionally, a limited number of non-oil and gas-related projects are proposed by EEPGL and others that could potentially impact the same types of resources that could be impacted by the Project.

The Project activities, other planned EEPGL activities, and non-EEPGL activities together could cumulatively impact some resources such as:

- Climate (via increased emissions of greenhouse gases);
- Marine mammals (via vessel strikes or potential acoustic injury or disturbance from underwater sound);
- Marine turtles (via vessel strikes);
- Marine fish (via degraded water quality and entrainment of fish from cooling and ballast water intakes);
- Community health and wellbeing (via increased demand on limited medical treatment capacity);
- Marine use and transportation (via additional marine congestion, especially near Georgetown Harbour);
- Social infrastructure and services (via increased demand for limited housing, utilities, and services; or via increased traffic congestion); and
- Waste management infrastructure capacity (via demand on hazardous waste treatment facilities and landfills).

Potential impacts described above that require offshore interaction between the Project and others have a limited chance of occurring, given the size of the Stabroek Block.

The Project will adopt a number of embedded controls, mitigation measures, and management plans. These are considered sufficient and appropriate to address the contributions of the

Project to potential cumulative impacts. With respect to the contributions of multiple EEPGL projects to cumulative impacts, it is recommended that EEPGL, when designing and undertaking these additional projects and activities, ensure that the same level of potential impact management be implemented for new projects as for the Yellowtail Project. In addition, with the intention of minimizing the potential interactions between effects of multiple projects, it is recommended that EEPGL actively manage, where feasible and practicable, the spatial and temporal overlap of their additional projects activities. These measures are expected to be sufficient to address contributions of the Project and other EEPGL projects to cumulative impacts.

12.4. DEGREE OF IRREVERSIBLE DAMAGE

The planned Project would not cause irreversible damage to any onshore areas of Guyana. There would be a very minor (approximately 0.66 square kilometer [0.26 square mile]) permanent loss of benthic habitat offshore as a result of the installation of wells, flowlines, and other subsea equipment, which may be proposed to be left in place upon decommissioning. However, this equipment can ultimately provide the substrate for recolonization of the impacted areas. Even in the unlikely event of a large marine oil spill, little irreversible damage would be expected, although it could take a decade or more for all resources to fully recover, depending on the volume and duration of the release, as well as the time of year.

12.5. PROJECT BENEFITS

The Project will generate benefits for the citizens of Guyana in several ways:

- Through revenue sharing with the Government of Guyana, as detailed in the Petroleum Agreement (PA) between the Government of Guyana and EEPGL et al., which was made available to the public in December 2017. The type and extent of benefits associated with revenue sharing will depend on how decision makers in government decide to prioritize and allocate funding for future programs, which is unknown to EEPGL and outside the scope of the EIA.
- By Project purchasing of in-country goods and services from Guyanese businesses in alignment with the PA and the EEPGL Local Content Plan approved by the Ministry of Natural Resources in June 2021.
- By hiring Guyanese nationals in alignment with the PA and the EEPGL Local Content Plan.
- Through the Greater Guyana Initiative, (a decade-long program funded by the Stabroek Block co-venturers, that provides $20 billion GYD ($100 million USD) in support of sustainable economic diversification and capacity development programs across Guyana.

In addition to direct revenue sharing, expenditures, employment, and strategic investments, the Project will also likely generate induced economic benefits. These induced benefits could result from the re-investment, hiring, and spending by Project-related businesses and/or workers, which in turn benefits other non-Project-related businesses and generates more local tax for the

government. These beneficial "multiplier" impacts are expected to occur throughout the Project life (at least 20 years).

12.6. SUMMARY

Table 12.6-1 provides a summary of the predicted residual impact significance ratings (taking into consideration proposed mitigation measures) for impacts on each of the resources that may potentially result from the planned Project activities in each Project stage (i.e., development well drilling/Subsea, Umbilicals, Risers, and Flowlines/FPSO installation, production operations, and decommissioning). For each resource, the table shows the highest residual impact significance rating among the potential impacts relevant to each Project stage. For each resource, the table also summarizes the highest residual risk rating for potential risks to resources from unplanned events (e.g., oil spill, vessel strike) and the priority rating for potential cumulative impacts on each resource, as determined by the cumulative impact assessment.

Table 12.6-1: Summary of Residual Impact Significance Ratings, Residual Risk Ratings, and Cumulative Impact Priority Ratings

Resource	Highest Residual Impact Significance Rating (Planned Project Activities)			Highest Residual Risk Rating (Unplanned Events)	Cumulative Impact Priority Rating
	Drilling and Installation	Production Operations	Decommissioning		
Air Quality, Climate, and Climate Change	Negligible	Moderate	Negligible	Minor	Low (Air Quality) Medium (Climate)
Sound [a]	None	None	None	None	NA
Marine Geology and Sediments	Negligible	None	None	Moderate	NA
Marine Water Quality	Minor	Negligible	Negligible	Moderate	Low
Protected Areas	None	None	None	Moderate	NA
Special Status Species: [b]					
• Terrestrial species and coastal marine fish	Negligible	Negligible	Negligible	Minor	Low
• Critically Endangered and Endangered Offshore Marine Fish	Moderate	Negligible	Negligible	Minor	Low
• Vulnerable offshore marine fish	Minor	Negligible	Negligible	Minor	Low
• Near threatened seabirds and endangered Black-capped Petrel (*Pterodroma hasitata*)	Negligible	Minor [d]	Negligible	Minor	Low
• Vulnerable Leach's Storm-Petrel (*Oceanodroma leucorhoa*)	Negligible	Minor [d]	Negligible	Moderate [e]	Low
Coastal Habitats	None	None	None	Moderate	NA
Coastal Wildlife	None	None	None	Minor	NA
Seabirds [c]	Negligible	Minor	Negligible	Minor	NA

Resource	Highest Residual Impact Significance Rating (Planned Project Activities)			Highest Residual Risk Rating (Unplanned Events)	Cumulative Impact Priority Rating
	Drilling and Installation	Production Operations	Decommissioning		
Marine Mammals	Minor	Minor	Negligible	Moderate	Medium
Riverine Mammals	Minor	Minor	Minor	Minor	Low
Marine Turtles	Negligible	Negligible	Negligible	Moderate	Low
Marine Fish [f]	Minor	Negligible	Negligible	Minor	Low
Marine Benthos	Negligible	Positive	Positive	Minor	NA
Ecological Balance and Ecosystems	Minor	Minor	Minor	Minor	Low
Socioeconomic Conditions [g]	Minor	Minor	Minor	Minor	Low
Employment and Livelihoods [h]	Minor	Minor	Minor	Minor	Low
Community Health and Wellbeing	Minor	Minor	Minor	Minor to Moderate	Low
Marine Use and Transportation:					
• Commercial cargo	Negligible	Negligible	Negligible	Minor	Low
• Commercial fishing	Minor	Minor	Minor	Minor	Low
• Subsistence fishing	Minor	Minor	Minor	Minor	Low
Social Infrastructure and Services:					
• Lodging	Minor	Negligible	Negligible	Minor	Low
• Housing and utilities	Minor	Negligible	Negligible	Minor	Low
• Ground transportation	Minor	Minor	Minor	Minor	Low
• Air transportation	Negligible	Negligible	Negligible	Minor	Low
Waste Management Infrastructure Capacity	Minor	Minor	Minor	Minor	Medium
Cultural Heritage	Negligible	None	None	Minor	NA
Land Use	Negligible	Negligible	Negligible	Minor	NA
Ecosystem Services	None	None	None	Minor	NA
Indigenous Peoples	None	None	None	Minor	NA

NA = not applicable (not assessed in cumulative impact assessment); scoped out as potentially eligible (see Chapter 10, Cumulative Impact Assessment)

[a] Potential underwater sound-related impacts on marine mammals, marine turtles, and marine fish are assessed in the resource-specific sections for those resources.

[b] Includes only seabirds and marine fish. Excludes listed marine turtles, listed marine mammals, and listed riverine mammals, which are covered in the Marine Turtles, Marine Mammals, and Riverine Mammals resource categories, respectively.

[c] Excludes listed seabirds, which are covered in the Special Status Species resource category.

[d] Based on the 20-year presence of the FPSO (as a lighted attractant), the potential impact significance to special status marine birds during the production operations stage is considered Minor.

[e] The residual risk rating for Leach's Storm-Petrel is considered Moderate based on the results of marine bird surveys in 2017, 2018, and 2019, which documented the importance of the offshore zone as a migratory corridor for this special status marine bird.

[f] Excludes listed marine fish, which are covered in the Special Status Species resource category.

[g] Reflects the highest residual impact significance rating for impacts to lower income subpopulation, although other impacts will be beneficial and therefore Positive.

[h] Reflects the highest residual impact significance rating for impacts to fisherfolk, although other impacts will be beneficial and therefore Positive.

13. RECOMMENDATIONS

The Consultants recommend the following measures be considered by the EPA, the Environmental Assessment Board, and other relevant Government of Guyana agencies as conditions of issuance of an environmental authorization for the Project:

- Embedded Controls—incorporate all of the proposed embedded controls (see Table 13-1).
- Mitigation Measures—adopt the recommended mitigation measures (see Table 13-2).
- Management Plans—implement the proposed Environmental and Socioeconomic Management Plan (ESMP) to manage and mitigate the potential impacts identified in the EIA. The ESMP includes the following:
  - ESMP Framework (Chapter 11)
  - Environmental Management Plan, including:
    - Air Quality Management
    - Water Quality Management
    - Waste Management
    - Marine Ecosystems Management
  - Socioeconomic Management Plan, including:
    - Stakeholder Engagement
    - Grievance Management
    - Transportation Management
    - Cultural Heritage Management, including Chance Finds
  - Emergency Response Plan Summary
  - Oil Spill Response Plan (OSRP), including oil spill modeling, Net Environmental Benefit Analysis, emergency preparedness and response procedures, Wildlife Response Plan, and geographic strategic response maps
  - Preliminary End of Operations Decommissioning Plan
  - Environmental and Socioeconomic Monitoring Plan
- Oil Spill Preparedness—EEPGL has proactively embedded multiple controls into the Project design to prevent a spill from occurring, and we agree that a large spill that affects the Guyana coastline and/or other regional coastlines is unlikely. But given the sensitivity of many of the resources that could potentially be impacted by a spill (e.g., Shell Beach Protected Area; marine mammals; critically endangered, endangered, and vulnerable marine turtles; and Amerindian, fishing, and other communities reliant on ecosystem services for sustenance and their livelihood), we believe it is critical that EEPGL commit to regular oil spill response drills, simulations, and exercises—and involve appropriate Guyanese authorities and stakeholders in these activities, document the availability of appropriate response equipment on board the Floating Production, Storage, and Offloading

(FPSO) vessel, and demonstrate that offsite equipment could be mobilized for a timely response.

With the adoption of such controls, mitigation measures, and management plans, and requirements for emergency response preparedness, the Yellowtail Development Project is expected to pose only minor risks to the environmental and socioeconomic resources of Guyana, while potentially offering significant economic benefits to the residents of Guyana.

Table 13-1: List of Proposed Embedded Controls

Embedded Controls	Resources/Receptors Benefited
Development Wells Drilling and Subsea, Umbilicals, Risers, and Flowlines (SURF)/FPSO Installation and Commissioning	
Use water-based drilling fluids to the extent reasonably practicable (upper sections of the wells). For well sections requiring non-aqueous drill fluid (NADF), use only low-toxicity International Oil and Gas Producers Group III base fluid.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
When NADF is used, use a solids control and cuttings dryer system to treat drill cuttings such that end-of-well maximum weighted mass ratio averaged over all well sections drilled using NADF does not exceed 6.9% wet weight base fluid retained on cuttings.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
Install a blowout preventer (BOP) system that can be closed rapidly in the event of an uncontrolled influx of formation fluids and that allows the well to be circulated to safety by venting the gas at surface and routing oil so that it may be contained.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
Test BOP equipment at installation, after disconnection or repair of any pressure containment seal, and at regular intervals (at least every 21 days or as operations allow).	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
Visually check and take appropriate measures to mitigate occurrence of free oil resulting from discharge of NADF drill cuttings.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
Employ trained Marine Mammal Observers during the conduct of seismic-related activities.	Marine mammals, marine turtles
Conduct a continuous observation of a mitigation zone (500 meters [1,640 feet] around the sound source) to verify whether it is clear of marine mammals and marine turtles before commencing sound producing seismic operations. Do not commence sound-producing seismic operations (including soft starts) if marine mammals or turtles are sighted within the mitigation zone during the 30 minutes prior to commencing sound-producing operations in water depths less than 200 meters [656 feet], or 60 minutes prior to commencing sound-producing operations in water depths greater than 200 meters [656 feet].	Marine mammals, marine turtles
Where reasonably practicable, equip sound-making devices or equipment with silencers or mufflers that are enclosed, and/or use soft-start procedures (e.g., for vertical seismic profiling, etc.) to reduce noise to levels that do not cause material harm or injury to marine species.	Marine mammals, marine fish, marine turtles

Embedded Controls	Resources/Receptors Benefited
Adhere to the Joint Nature Conservation Committee guidelines (JNCC 2017) during the conduct of seismic-related activities.	Marine mammals, marine turtles
If well testing[1] is performed, implement the following measures: • Flow only the minimum volume of hydrocarbons required for the test and reduce the test duration to the extent practical; • Use an efficient test-flare burner head equipped with an appropriate combustion enhancement system to minimize incomplete combustion, black smoke, and hydrocarbon fallout[2] to the sea; • Provide adequate gas sensors that are appropriately located during testing operations so that all sources of gas can be detected; • Monitor pipes and joints on a daily basis for leakages and fugitive emissions. Burn all collected gaseous streams in high-efficiency flares, and implement and maintain a leak detection and repair program; • Keep the well test to the minimum practical time, in keeping with a pre-approved schedule with the EPA. Notify the EPA immediately in case of any deviation/variation to the well test; and • Provide sufficient compressed air to the oil burner for efficient flaring assignment.	Air quality, climate, and climate change
With respect to prevention of spills of hydrocarbons and chemicals during the drilling stage: • Change liquid hydrocarbon transfer hoses periodically; • Use dry-break connections on liquid hydrocarbon bulk transfer hoses; • Perform required inspections and testing of all equipment prior to deployment/installation; • Use overbalanced drilling fluids to control wells while drilling; • Perform operational training certification (including well-control training) for drill ship supervisors and engineers; • Use controls for mitigating a failure of the Dynamic Positioning (DP) system on the drill ships and maintaining station-keeping, which include: – Use of a Class 3 DP system, which includes numerous redundancies; – Rigorous personnel qualifications and training; – Sea trials and acceptance criteria; – DP proving trials; – System Failure Mode and Effects Analysis; – DP failure consequence analysis; and – Establishment of well-specific operations guidelines.	Marine geology and sediments, marine water quality, protected areas and special status species, coastal habitats, coastal wildlife, marine mammals, marine turtles, marine fish, marine benthos, ecological balance and ecosystems
Prior to and post-drilling, a remotely operated vehicle will take pictures of the area immediately surrounding the well location to monitor for marine water quality impacts.	Marine geology and sediments, marine water quality, protected areas and special status species, marine mammals, marine turtles, marine fish, marine benthos, ecological balance and ecosystems

[1] While well testing is not planned for the Project, there is the potential it could be needed, in which case EEPGL will implement the measures in Table 13-1

[2] Hydrocarbons that are deposited on the ocean surface due to both wet and dry deposition processes

Embedded Controls	Resources/Receptors Benefited
Maintain marine safety exclusion zones to be issued through the Maritime Administration Department with a 500-meter (approximately 1,640-foot) radius around drill ships and major installation vessels, to prevent unauthorized vessels from entering areas with an elevated risk of collision.	Marine use and transportation
For all vessel effluent discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage), comply with the International Maritime Organization and International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Install subsea BOP systems consisting of one annular preventer, two shear ram preventers, one of which must be sealing, and two pipe ram preventers, and equip them with choke and kill lines and failsafe choke and kill close valves.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Facility personnel should conduct bi-weekly well-control drills, or as operations allow, which should be attended by key personnel.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Utilize a BOP that is able to close on the maximum outside-diameter drill pipe string used for the drilling operations and that contains a safety system to secure the well in the event of a loss-of-control signal and hydraulic supply from the surface to the BOP. At a minimum, subsea BOP systems should allow closure of one set of pipe rams and blind-shearing type rams by remotely operated vehicle intervention if required.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Prepare contingency plans for well operations that include identification of provisions for well capping in the event of uncontrolled blowout (providing indication of the tools, equipment, and intervention time required) and identification of spill recovery measures.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Production Operations	
Use aero-derivative turbines instead of industrial turbines on the FPSO.	Air quality, climate, and climate change
Install waste heat recovery units on turbine generators to reduce the demand of more power generation or fired heaters, thus decreasing fuel gas consumption.	Air quality, climate, and climate change
Use a crude–crude exchanger to recover heat from the dead crude to heat up live crude, instead of using a fired heater.	Air quality, climate, and climate change
Use a gas turbine to drive the export/injection compressors directly, allowing savings in fuel versus using a gas turbine to generate electricity, and then using an electric motor to drive the compressor—reducing motor losses and power generation losses.	Air quality, climate, and climate change
Use large, high-voltage motors, which are more efficient than industry standard machines.	Air quality, climate, and climate change
Provide installed spares on compressors for the Flash Gas Compression, Main Gas Compression, and Re-injection Gas Compression systems, such that when one compressor trips, the spare (backup) unit can be started, hence reducing non-routine flaring frequency and volume/duration.	Air quality, climate, and climate change

Embedded Controls	Resources/Receptors Benefited
Implement an FPSO topsides leak detection and repair program to reduce fugitive emissions.	Air quality, climate, and climate change
Implement a flare minimization plan for the Project.	Air quality, climate, and climate change
Instead of continuous flaring of gas produced during crude oil production, re-inject associated gas that is not used as fuel gas on the FPSO—excluding *de minimis* sources not captured by the Vapor Recovery Unit—into the reservoir, to avoid routine flaring of associated gas.	Air quality, climate, and climate change
Use highly efficient combustion equipment that utilizes recovery heat systems as part of the heat and power production.	Air quality, climate, and climate change
With respect to non-routine flaring of associated gas, the following measures will be implemented: • Properly inspect, maintain, monitor, certify, and function-test flare equipment prior to and throughout operations; • Design and build combustion equipment to appropriate engineering codes and standards; • Use flare tip of a non-pollutant type, with low nitrogen oxides emissions, and a burning efficiency high enough to support low hydrocarbon emissions to the atmosphere; • Minimize risk of pilot blowout by ensuring sufficient exit velocity and provision of wind guards; • Use a reliable pilot ignition system; • Install high-reliability instrument pressure protection systems, as appropriate, to reduce overpressure events and avoid or reduce flaring situations; • Minimize liquid carryover and entrainment in the gas flare stream with a suitable liquid separation system, with sufficient holding capacity for liquids that may accumulate, and which is designed in accordance with good engineering practice; • Equip liquid separation system (e.g., knockout drum) with high-level facility shutdown or high-level alarms and empty as needed to increase flare combustion efficiency; • Implement source gas reduction measures (i.e., gas re-injection into reservoir) to the extent possible to avoid or reduce flaring from FPSO; • Minimize flaring from purges and pilots without compromising safety through measures such as installation of purge gas reduction devices, vapor recovery units, inert purge gas, and soft seat-valve technology where appropriate, and installation of pilot flares; and • Minimize flame lift off and/or flame lick.	Air quality, climate, and climate change
Employ reasonable efforts and execute a maintenance program to minimize equipment breakdowns and plant upsets that could result in flaring, and make provisions for equipment sparing and plant turn-down protocols where practical.	Air quality, climate, and climate change
Implement inspection, maintenance, and surveillance programs to identify and prevent unplanned emissions to atmosphere onboard the FPSO.	Air quality, climate, and climate change
Adopt measures as far as practicable, in accordance with the Global Gas Flaring and Venting Reduction Partnership when	Air quality, climate, and climate change

Embedded Controls	Resources/Receptors Benefited
considering venting and flaring options under emergency or upset conditions.	
Avoid routine venting (excludes tank flashing emissions, standing/ working/breathing losses, secondary seals) except during safety and emergency conditions.	Air quality, climate, and climate change
Treat produced water onboard the FPSO to an acceptable specification prior to discharging. Measure oil and grease content of produced water (grab sample once per day). Limit oil content of discharged produced water to 42 milligrams per liter (mg/L) on a daily basis or 29 mg/L on a monthly average. If oil content of produced water is observed to exceed these limits, route it to an appropriate storage tank on the FPSO until the treatment system is restored and the discharge meets the noted specification.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Design cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3°C (5.4°F) at 100 meters (approximately 328 feet) from discharge point.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Evaluate available alternatives for antifouling chemical dosing to prevent marine fouling of offshore facility cooling water systems. Where practical, optimize seawater intake depth to reduce the need for use of chemicals.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Monitor residual chlorine concentration of sewage discharges from the FPSO monthly to stay below 0.5 mg/L in accordance with MARPOL 73/78 regulations.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
For effluent released from the onboard sewage treatment plant, comply with aquatic discharge standards in accordance with MARPOL 73/78 regulations.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Perform daily visual inspections on the FPSO of discharge points to verify that there are no floating solids or discoloration of the surrounding waters.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Maintain marine safety exclusion zones to be issued through the Maritime Administration Department with a 2-nautical-mile (approximately 12,150-foot) radius around FPSO during offloading operations, to prevent unauthorized vessels from entering areas with an elevated risk of collision.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Employ dedicated Mooring Master to supervise offloading activities, according to the conditions of the sea. The conditions and characteristics of the export tankers will be assessed by the Mooring Master and reported to the Offshore Field Manager prior to commencing offloading operations. Use only properly registered and well-maintained double-hull vessels.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use support tugs to aid tankers in maintaining station during approach/departure from FPSO and during offloading operations.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Adopt risk assessment processes (e.g., hazard and operability study, hazard identifications study, etc.) to assess risks	Marine use and transportation, marine geology and sediments,

Embedded Controls	Resources/Receptors Benefited
associated with process upset and loss-of-containment events which could impact the environment.	marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use a hawser with a quick release mechanism to moor the FPSO to the tanker at a safe separation distance during offloading operations.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Establish operating conditions for FPSO offloading to tankers to support safe operations. In the event that adverse weather occurs during offloading operations that is beyond the environmental operating limit, the tanker will cease offloading operations, and may disconnect and safely maneuver away from the FPSO as appropriate.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use breakaway couplers on offloading hose that would stop the flow of oil from FPSO during an emergency disconnect scenario.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use a liquid hydrocarbon checklist before every bulk transfer.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use a load-monitoring system in the FPSO control room to support FPSO offloading.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Utilize procedures for loading, storage, processing, and offloading operations, either for consumables (i.e., fuel, drilling fluids, and additives) or for liquid products, to minimize spill risks. Inspect pumps, hoses, and valves on a monthly basis, and perform maintenance as needed.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use leak detection controls during FPSO offloading (e.g., for breach of floating hose, instrumentation/procedures to perform volumetric checks).	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Install an Emergency Shutdown System on the FPSO to initiate automatic shutdown actions to bring the offshore facility to a safe condition and which should be activated in case of any significant release.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Implement a corrosion management system to monitor risks and identify corrective actions in the atmospheric zone, splash zone, submerged zone, and internal zones.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Inspect and maintain onboard equipment (engines, compressors, generators, sewage treatment plant, and oil-water separators) in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, in order to maximize efficiency and minimize malfunctions, and unnecessary discharges into the environment.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Use low-sulfur (less than 0.5% sulfur content) fuels and/or natural gas on all Project vessels in turbines, reciprocating engines, or	Air quality, climate, and climate change

Embedded Controls	Resources/Receptors Benefited
boilers used for heat or power generation or to drive machinery such as compressors or pumps.	
Abide with International Maritime Organization guidelines (IMO 2004) including the International Convention for the Control and Management of Ship's Ballast Water and Sediments, with the exception of Regulation D-2 (Ballast Water Performance Standard) while the FPSO is on station, and abide with the MARPOL 73/78.	Ecological balance and ecosystems
General Measures	
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.	Air quality, climate, and climate change; sound; marine water quality; marine mammals; marine turtles; riverine mammals
Implement engineering controls, administrative controls, and training to protect offshore workforce from high noise levels in the offshore work environment.	Sound
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Equip Project vessels with radar systems and communication mechanisms to communicate with third-party mariners.	Marine use and transportation
Shut down (or throttle down) sources of combustion equipment in intermittent use where reasonably practicable in order to reduce air emissions.	Air quality, climate, and climate change
Implement chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes; • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties, while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Minimum safety risk relative to flammability and volatility; and • Risk evaluation of residual chemical releases into the environment.	Air quality, climate, and climate change; marine water quality; marine geology and sediments; marine mammals; marine turtles; riverine mammals; marine fish; marine benthos; seabirds
Utilize low toxicity chemicals/materials where practical. Each chemical/material should be managed in accordance with the associated Safety Data Sheet.	Air quality, climate, and climate change; marine water quality; marine geology and sediments; marine mammals; marine turtles; riverine mammals; marine fish; marine benthos; seabirds
Use secondary containment for storage of bulk fuel, drilling fluids, and hazardous materials, where reasonably practicable.	Marine water quality
Regularly (e.g., monthly) check pipes, storage tanks, and other equipment associated with storage or transfer of hydrocarbons/chemicals for leaks and fugitive emissions.	Marine water quality

Embedded Controls	Resources/Receptors Benefited
For effluent released from the onboard sewage treatment plant, comply with aquatic discharge standards in accordance with MARPOL 73/78 regulations.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Treat food waste in accordance with MARPOL 73/78 (e.g., food comminuted to 25-millimeter-diameter [approximately 1-inch-diameter] particle size or less) prior to discharge.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
For transport of hazardous and nonhazardous wastes offsite for treatment or disposal, confirm the waste is accompanied by a manifest signed by the hazardous waste generator, transporter, and receiving facility.	Waste management infrastructure capacity
Return radioactive sources to their supplier and manage radioactive sources in accordance with environmental permits and applicable safety standards.	Waste management infrastructure capacity
Secure and contain fuel, oils, and chemicals in accordance with their Safety Data Sheet recommendations.	Waste management infrastructure capacity
Provide for adequate onshore waste-management equipment and facilities for the proper management of waste in accordance with local regulation and good international oilfield practice.	Waste management infrastructure capacity
For wastes that cannot be reused, treated, or discharged/disposed on the drill ships or FPSO, properly manifest and transfer such wastes to appropriate onshore facilities for management.	Waste management infrastructure capacity
Sample and perform analytical testing as needed to properly classify waste.	Waste management infrastructure capacity
Complete Recoverable Material and Waste Summaries.	Waste management infrastructure capacity
Periodically audit waste contractors to verify appropriate waste management practices are being used.	Waste management infrastructure capacity
Record type and quantity of each individual waste stream on board vessels any time a new waste is generated.	Waste management infrastructure capacity
Inspect on a regular basis waste storage areas and containers; log inspections.	Waste management infrastructure capacity
Avoid, reduce, and reuse/recycle wastes preferentially prior to disposal in accordance with waste management hierarchy.	Waste management infrastructure capacity
Perform onshore waste treatment for certain categories of waste, thereby reducing demand on landfill capacity.	Waste management infrastructure capacity
Confirm there is no visible oil sheen from commissioning-related discharges (i.e., flowlines/risers commissioning fluids, including hydrotesting waters) or FPSO cooling water discharge. Perform daily inspections to verify no visible sheen from discharge of cooling water.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Treat bilge water in accordance with MARPOL 73/78 to comply with an oil-in-water content of less than 15 parts per million, as applicable. Perform oil in water content (automatic) monitoring of bilge water to verify compliance with 15 parts per million and record in Oil Record Book.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds

Embedded Controls	Resources/Receptors Benefited
Provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals and riverine mammals at the sea surface. Provide standing instruction to Project-dedicated vessel masters to avoid marine mammals, riverine mammals, and marine turtles while underway and reduce speed or deviate from course, when possible, to reduce probability of collisions.	Marine mammals, marine turtles, riverine mammals
Provide standing instruction to Project-dedicated vessel masters to avoid any identified rafting seabirds when transiting to and from Project Development Area.	Seabirds
Provide standing instructions to Project-dedicated vessel masters to reduce their speed within 300 meters (984 feet) of observed marine mammals and marine turtles, and to not approach the animals closer than 100 meters (328 feet).	Marine turtles
Observe standard international and local navigation procedures in and around the Georgetown Harbour and Demerara River, as well as best ship-keeping and navigation practices while at sea.	Marine use and transportation
Provide health-screening procedures to Project workers to reduce risks of transmitting communicable diseases.	Community health and wellbeing
Monitor Project workers' occupational exposure to sound.	Community health and wellbeing
Test for diseases that are communicable through normal medical screening/surveillance.	Community health and wellbeing
Employ Guyanese citizens having the appropriate qualifications and experience where reasonably practicable.	Socioeconomic conditions, employment and livelihoods
Partner with select local institutions and agencies to support workforce development programs targeted to in-demand skillsets, and proactively message Project-related employment opportunities.	Socioeconomic conditions, employment and livelihoods
Procure Project goods and services from Guyanese suppliers when available on a timely basis and when they meet minimum standards and are commercially competitive.	Socioeconomic conditions, employment and livelihoods
Monitor percentage of Project Workforce made up of Guyanese nationals on a quarterly basis.	Socioeconomic conditions, employment and livelihoods
Monitor percentage of Project goods and services expenditures procured locally on a quarterly basis.	Socioeconomic conditions, employment and livelihoods
Develop and implement a Stakeholder Engagement Plan.	Community health and wellbeing
Implement a transparent, accessible, and consistent Community Grievance Mechanism (CGM) early on, prior to onset of Project activities.	Community health and wellbeing
Monitor grievances received and resolved by the CGM; adjust CGM and other management measures, as appropriate	Community health and wellbeing
Implement a community safety program for potentially impacted schools and neighborhoods to increase awareness and minimize potential for community impacts due to vehicle incidents.	Social infrastructure and services, community health and wellbeing
Implement a Road Safety Management Procedure to mitigate increased risk of vehicular accidents associated with Project-related ground transportation activities. The Road Safety Management Procedure has been implemented as of the writing of this EIA, and the procedure includes the following components:	Social infrastructure and services, community health and wellbeing

Embedded Controls	Resources/Receptors Benefited
• Definition of typical, primary travel routes for ground transportation in Georgetown area; • Development of an onshore logistics/journey management plan to reduce potential conflicts with local road traffic when transporting goods to/from onshore support facilities; • Definition of required driver training for Project-dedicated drivers, including (but not limited to) defensive driving, loading/unloading procedures, and safe transport of passengers, as applicable; • Designation and enforcement of speed limits through speed governors, global positioning system, or other monitoring systems for Project-dedicated vehicles; • Avoidance of deliveries during typical peak-traffic hours as well as scheduled openings of the Demerara Harbour Bridge, to the extent reasonably practicable; • Monitoring and management of driver fatigue; • Definition of vehicle inspection and maintenance protocols that include all applicable safety equipment for Project-dedicated vehicles; and • Community outreach to communicate information relating to major delivery events or periods.	
Coordinate with relevant aviation authorities and stakeholders to understand peak Project-related utilization rates.	Social infrastructure and services
Use an established Safety, Security, Health, and Environment program to which all Project workers and contractors will be required to adhere to mitigate against risk of occupational hazards. Require all workers and contractors to receive training on implementation of these principles and to adhere to them in the daily execution of their duties.	Occupational health and safety
Maintain an OSRP to support an effective response to an oil spill, including maintaining the equipment and other resources specified in the OSRP. Conduct periodic inspections, training and drills including monthly inspection of oil spill response equipment, quarterly test runs of oil spill response equipment, annual preventive maintenance program execution, and annual exercise and deployment of oil spill response equipment to test readiness and response capability.	All resources and receptors potentially impacted by an oil spill
Where reasonably practicable, direct lighting on FPSO and major Project vessels to required operational areas rather than at the sea surface or skyward. Adhere to maritime safety regulations/standards for lighting on vessels.	Seabirds, marine turtles
Provide screening for seawater intakes to avoid entrainment and impingement of marine flora and fauna.	Marine fish

Table 13-2: List of Proposed Mitigation Measures

Proposed Mitigation Measure	Resources/Receptors Benefited
Install volatile organic compound recovery on the FPSO cargo tanks, which results in a reduction in FPSO cargo tank emissions.	Air quality, climate, and climate change
Install vapor recovery unit for low-flow process streams from produced water and triethylene glycol regeneration, resulting in a reduction in emissions to the atmosphere.	Air quality, climate, and climate change
Optimize gas turbine maintenance so that gas turbines are not overhauled more often than needed, and so that overhauls are completed at the right time, in alignment with other FPSO maintenance activities to reduce the need to flare.	Air quality, climate, and climate change
Implement trip reduction initiatives for the gas turbines to improve reliability/ availability and thus reduce flaring.	Air quality, climate, and climate change
Following start-up of production operations, implement a program to characterize effluent water discharges from the FPSO and conduct an environmental risk assessment based on the characterization data. As appropriate based on the results of the environmental risk assessment, implement additional treatment options, if warranted and feasible.	Marine water quality, seabirds, marine mammals, marine turtles, marine fish, marine benthos, ecological balance and ecosystems
Notices to Mariners are issued through the Maritime Administration Department for their communication with the public, and information is provided to the Department of Fisheries for their distribution to stakeholders (including associations, co-ops, and fisherfolk) within the fishing industry in country, regarding movements of major marine vessels (including the FPSO, drill ship, and installation vessels)—to aid them in avoiding areas with concentrations of Project vessels and/or where marine safety exclusion zones are active..	Employment and livelihoods, marine use and transportation
Augment ongoing stakeholder engagement process (along with relevant authorities) to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners and, where possible, communicate with them regarding major vessel movements and marine safety exclusion zones.	Employment and livelihoods, marine use and transportation
Promptly remove damaged Project vessels (associated with any vessel incidents) to minimize impacts on marine use, transportation, and safety.	Marine use and transportation
Proactively communicate the Project's limited staffing requirements as a measure to reduce the magnitude of potential population influx to Georgetown from job seekers.	Social infrastructure and services
Adopt and implement as needed a Chance Find Procedure that describes the requirements in the event of a potential chance find of heritage or cultural resources.	Cultural heritage
EEPGL will train Project and contractor personnel with the potential to identify underwater chance finds so that these operators are informed about the identification of chance finds, appropriate use of the Chance Find Procedure, and monitoring and reporting requirements.	Cultural heritage
Require Project workers to adhere to a Worker Code of Conduct, which will address shore-leave considerations.	Community health and wellbeing
Use a dedicated medical provider to complement the services of the local private medical clinic used by the Project, and procure a dedicated ambulance to avoid overwhelming the local medical infrastructure (ambulance has already been procured as of the writing of this EIA).	Community health and wellbeing

Proposed Mitigation Measure	**Resources/Receptors Benefited**
Implement the OSRP in the unlikely event of an oil spill, including: • Conducting air quality monitoring during emergency response; • Requiring use of appropriate personal protective equipment by response workers; and • Implementing a Wildlife Oil Response Program, as needed.	All resources potentially affected by an oil spill
Implement a claims process and, as applicable, a livelihood remediation program to address economic losses or impacts on livelihood as a result of an oil spill.	Socioeconomic conditions, community health and wellbeing, employment and livelihoods, Indigenous Peoples, ecosystem services
Communicate EEPGL's health, safety, and security standards and requirements to interested vendors and contractors, as appropriate.	Social infrastructure and services
In case of a collision involving a Project vessel and a non-Project vessel that may result in a claim arising from such type of incident, provide appropriate restitution, consistent with governing contracts and applicable laws.	Socioeconomic conditions, employment and livelihoods
To address future waste capacity constraints in Georgetown relative to Project's predicted waste management needs: • As warranted based on anticipated future EEPGL hazardous waste generation trends and trends in non-EEPGL hazardous waste generation, continue enabling the expansion of existing local waste management capacity for hazardous wastes, and explore use of new local hazardous waste treatment facilities, or identify suitable alternative solutions. • Continue monitoring of plans for further expansion of the Haags Bosch Landfill and/or (if approved by the EPA) construction of additional landfill sites in other locations (as decided by the government), or identify suitable alternative (interim) local solutions for non-hazardous waste management.	Waste management infrastructure and capacity

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14. PROJECT TEAM

Table 14-1 identifies the core members of the Consultant team and their roles in preparing the Project EIA.

Table 14-1: Core Project Team Members

Member	Company and Position	Role
Todd Hall	ERM: Program Lead	Overall program lead for the ExxonMobil Guyana program; cumulative impact assessment; technical review of EIA Physical Resources chapter
Steve Koster	ERM: Partner in Charge	Overall lead for regulatory engagement, EIA process execution, and deliverable production; technical review of EIA Socioeconomic chapter
Camilo Gaona	ERM: Partner	Logistics management, subcontractor management, regulatory interface
Jason Willey	ERM: Project Manager	Overall day-to-day management of technical execution for EIA process; technical review of EIA Biological Resources chapter
Nickolas Chin	ERM: Health and Safety Lead	Health and safety
Neil Henry	ERM: Consultant Coordinator	Logistics and other local support for field studies and stakeholder engagement
Paul Bonar	CEMCO: Consultant Coordinator	Contributor to EIA Physical Resources chapter
Elford Liverpool	University of Guyana: Consultant Coordinator/ Zoologist	Contributor to EIA Biological Resources chapter
Leon Moore	Leon Moore Nature Experience: Consultant Coordinator/ Zoologist	Contributor to EIA Biological Resources chapter
Noam Raffel	ERM: GIS Specialist	Technical lead for GIS
Haimwant Persaud	CEMCO: GIS Specialist	General GIS support
Amberly Moon	ERM: Biodiversity Specialist	Technical lead for EIA Biological Resources chapter
Mark Ram	University of Guyana: Biodiversity Specialist	Contributor to EIA Biological Resources chapter
Indranee Roopsind	Leon Moore Nature Experience: Biodiversity Specialist	Contributor to EIA Biological Resources chapter
Leanna Kalicharan	University of Guyana: Marine Science Specialist	Contributor to EIA Biological Resources chapter
Mark Irvine	ERM: Physical Oceanographic Specialist	Technical lead for EIA Physical Resources chapter
Catriona Munro	ERM: Marine Scientist/Biological Oceanographic Specialist	Contributor to EIA Physical Resources chapter
Hemwantie Singh	CEMCO: Marine Water Quality Specialist	Contributor to EIA Physical Resources chapter
Michael Lowe	CEMCO: Environmental Health and Safety	Contributor to Environmental and Social Management Plan

Member	Company and Position	Role
Shwet Prakash	ERM: Hydrodynamic Modeling Specialist t	Technical lead for marine water quality modeling and impact assessment
Jacob Guise	ERM: Hydrodynamic Modeling Specialist	Contributor to EIA Physical Resources chapter
Mark Garrison	ERM: Air Quality Modeling Specialist	Technical lead for air quality dispersion modeling and air quality and climate impact assessment
Olga Samani	ERM: Air Quality Modeling Specialist	Contributor to air quality dispersion modeling
Surya Ramaswamy	ERM: Air Quality Modeling Specialist	Contributor to EIA Physical Resources chapter
Anna Sundby	ERM: Socioeconomic Resources / Stakeholder Engagement Specialist	Technical lead for EIA Socioeconomic Resources chapter
Candice Ramessar	ERM: Socioeconomic Resources / Stakeholder Engagement Specialist	Contributor to EIA Socioeconomic Resources chapter
Ashanta Osborne	CEMCO: Social Specialist	Contributor to EIA Socioeconomic Resources chapter
Amanda Sahai-Alli	CEMCO: Social Specialist	Contributor to EIA Socioeconomic Resources chapter

15. REFERENCES

Environmental Impact Statement

BSEE (Bureau of Safety and Environmental Enforcement). 2016. Worst Case Discharge Analysis (Volume I, February 2016).

EPA (Guyana Environmental Protection Agency). 2004. Volume 1 Environmental Impact Assessment Guidelines: Rules and Procedures for Conducting and Reviewing EIAs. Version 5. 34 pp.

EPA/EAB (Guyana Environmental Protection Agency/Environmental Advisory Assessment Board). 2000. Environmental Impact Assessment Guidelines. Volume 2-Generic. Version 4 November 2000. Environmental Protection Agency/Environmental Assessment Board.

IMO (International Maritime Organization). 2004. Regulations of the Prevention of Pollution by Sewage from Ships. 16 February 2004. Accessed: July 2021. Retrieved from: http://library.arcticportal.org/1913/1/International%20Convention%20for%20the%20Control%20and%20Management%20of%20Ships%27%20Ballast%20Water%20and%20Sediments.pdf

World Bank. 2015. *Environmental, health, and safety guidelines for offshore oil and gas development (English)*. IFC E&S. Washington, D.C.: World Bank Group. Accessed: July 2021. Retrieved from: https://documents1.worldbank.org/curated/en/378221479466912449/pdf/110348-FINAL-Jun-2015-Offshore-Oil-and-Gas-EHS-Guideline-PUBLIC.pdf

Chapter 1 Introduction

EPA (Guyana Environmental Protection Agency). 2004. Volume 1 Environmental Impact Assessment Guidelines: Rules and Procedures for Conducting and Reviewing EIAs. Version 5. 34 pp.

EPA/EAB (Guyana Environmental Protection Agency/Environmental Advisory Assessment Board). 2000. Environmental Impact Assessment Guidelines. Volume 2-Generic. Version 4 November 2000. Environmental Protection Agency/Environmental Assessment Board.

World Bank. 2015. *Environmental, health, and safety guidelines for offshore oil and gas development (English)*. IFC E&S. Washington, D.C.: World Bank Group. Accessed: July 2021. Retrieved from: https://documents1.worldbank.org/curated/en/378221479466912449/pdf/110348-FINAL-Jun-2015-Offshore-Oil-and-Gas-EHS-Guideline-PUBLIC.pdf

Chapter 2 Description of the Project

Abou-Sayed, Ahmed S., Karim S. Zaki, Gary Wang, Manoj Dnyandeo Sarfare, and Martin H. Harris. 2005. “Produced Water Management Strategy Water-Injection Best Practices—Design, Performance, Monitoring.” Paper presented at the International Petroleum Technology Conference, Doha, Qatar, November 2005. doi: https://doi.org/10.2523/IPTC-10548-MS

_____. 2007. “Produced Water Management Strategy and Water Injection Best Practices: Design, Performance, and Monitoring.” SPE Prod & Oper 22 (2007): 59–68. doi: https://doi.org/10.2118/108238-PA

Bedrikovetsky, P., E. Mackay, R.P. Monteiro, F. Patricio, and F.F Rosario. 2006. “Injectivity Impairment Due to Sulfate Scaling During PWRI: Analytical Model.” *SPE 100512*.

Bezerra, M.C.M., F.F. Rosario, and K.R.F.S.A. Rosa. 2013. “Scale Management in Deep and Ultradeep Water Fields.” *OTC 24508*.

Bryan, Jarryl. 2021. “US$436M in Guyana’s Natural Resource Fund.” *Guyana Times*. 10 August 2021. Accessed: October 2021. Retrieved from: https://guyanatimesgy.com/us436m-in-guyanas-natural-resource-fund/?__cf_chl_jschl_tk__=pmd_31e102c8b6dfd0db884a5f44efe8540eb22df59d-1628705335-0-gqNtZGzNAfijcnBszQlO

Dumas, Guilherme E. S., Ednilson B. Freire, Paulo R. S. Johann, Luciana S. Silva, Roberto A. B. Vieira, Carlos H. L. Bruhn, and Antonio C. C. Pinto. 2018. “Reservoir Management of the Campos Basin Brown Fields.” Paper presented at the Offshore Technology Conference, Houston, Texas, USA, April 2018. doi: https://doi.org/10.4043/28657-MS

Guo, B., and A. Ghalambor. 2005. *Natural Gas Engineering Handbook*. Gulf Publishing, Houston, Texas, USA.

Evans, Paul, Eduard Nederlof, and Will Richmond. 2015. “Souring Development Associated with PWRI in a North Sea Field.” Paper presented at the SPE Produced Water Handling & Management Symposium, Galveston, Texas, USA, May 2015. doi: https://doi.org/10.2118/174529-MS

ExxonMobil. 2021. “ExxonMobil announces oil discovery at Whiptail, offshore Guyana.” 28 July 2021. Accessed: October 2021. Retrieved from: https://corporate.exxonmobil.com/News/Newsroom/News-releases/2021/0728_ExxonMobil-announces-oil-discovery-at-Whiptail-offshore-Guyana

Hagan, Joseph T., Laurence R. Murray, T. Meling, Quanxin Guo, John D. McLennan, Ahmed S. Abou-Sayed, and T.G. Kristiansen. 2002. “Engineering and Operational Issues Associated with Commingled Drill Cuttings andProduced Water Re-injection Schemes.” Paper presented at the SPE International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, Kuala Lumpur, Malaysia, March 2002. doi: https://doi.org/10.2118/73918-MS

IAEA (The International Atomic Energy Agency). 2014. Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards. IAEA Safety Series No. GSR Part 3. Accessed: July 2021. Retrieved from: https://www-pub.iaea.org/MTCD/publications/PDF/Pub1578_web-57265295.pdf

IMO (International Maritime Organization). 1989. International Regulations (MARPOL 73/78). "Safety Zones and Safety of Navigation around Offshore Installations and Structures." Resolution A.671 (16). Adopted on 19 October 1989.

_____. 2003. International Regulations (MARPOL 73/78). "Revised Guidelines and Specifications for Pollution Prevention Equipment for Machinery Space Bilges of Ships." Annex 13. Resolution MEPC. 107(49). Adopted on 18 July 2003.

_____. 2004a. Regulations of the Prevention of Pollution by Sewage from Ships. 16 February 2004. Accessed: July 2021. Retrieved from: http://library.arcticportal.org/1913/1/International%20Convention%20for%20the%20Control%20and%20Management%20of%20Ships%27%20Ballast%20Water%20and%20Sediments.pdf

_____. 2004b. International Convention for the Control and Management of Ships' Ballast Water. BWM/CONF/36. 1 April 2004. Accessed: February 2022. Retrieved from: http___www.aphref.aph.gov.au_house_committee_jsct_march2003_treaties_annexiv-text.pdf

_____. 2018. Simplified overview of the discharge provisions of the revised MARPOL Annex V which entered into force on 1 March 2018. Accessed: March 2022. Retrieved from: https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Simplified%20overview%20of%20the%20discharge%20provisions%20of%20the%20revised%20MARPOL%20Annex%20V.pdf

IOGP (International Association of Oil & Gas Producers). 2003. Environmental fates and effects of ocean discharge of drill cuttings and associated drilling fluids from offshore oil & gas operations. Report 342. May 2003.

_____. 2015. Environmental performance: six ways IOGP is increasing transparency. 24 February 2015. Accessed: July 2021. Retrieved from: https://www.iogp.org/blog/data-series/environmental-performance-six-ways-iogp-is-increasing-transparency/

_____. 2016a. *Drilling waste management technology review*. Report 557. June 2016.

_____. 2016b. Environmental fates and effects of ocean discharge of drill cuttings and associated drilling fluids from offshore oil and gas operations. Report 543. March 2016.

JNCC (Joint Nature Conservation Committee). 2017. JNCC Guidelines for Minimising the Risk of Injury to Marine Mammals from Geophysical Surveys. Accessed: July 2021. Retrieved from: https://data.jncc.gov.uk/data/e2a46de5-43d4-43f0-b296-c62134397ce4/jncc-guidelines-seismicsurvey-aug2017-web.pdf

Kan, A.T., and M. B. Tomson. 2010. "Scale Prediction for Oil and Gas Production." *SPE 132237*.

Kelland, Malcolm. 2009. *Production Chemicals for the Oil and Gas Industry*. Boca Raton: CRC Press.

Liu, X., T. Chen, P. Chen, H. Montgomerie, T. Hagen, B. Wang, and X. Yang. 2012. "Understanding Mechanisms of Scale Inhibition Using Newly Developed Tests Method and Developing Synergistic Combined Scale Inhibitors." *SPE 156008*.

Mackay, E.J., I.R. Collins, M.M. Jordan, and N. Feasey. 2003. "PWRI: Scale Formation Risk Assessment and Management." Paper presented at the International Symposium on Oilfield Scale, Aberdeen, United Kingdom, January 2003. doi: https://doi.org/10.2118/80385-MS

Mainguy, M., S. Perrier, and E. Bure. 2020. "Produced-Water Reinjection in Deep Offshore Miocene Reservoirs, Block 17, Angola." *SEP 197061*.

Netusil, M., and P. Ditl. 2010. "Comparison of Methods for Dehydration of Natural Gas Stored in Underground Storage." *Journal of Applied Chemistry* 49(2): 87-88

Onaisi, Atef, Jalel Ochi, Marc Mainguy, and Phillipe Souillard. 2011. "Modeling Non-Matrix Flow and Seals Integrity in Soft Sand Reservoirs." Paper presented at the SPE European Formation Damage Conference, Noordwijk, The Netherlands, June 2011. doi: https://doi.org/10.2118/144801-MS

OPRED (Offshore Petroleum Regulator for Environment and Decommissioning). 2018. Guidance Notes: Decommissioning of Offshore Oil and Gas Installations and Pipelines. November 2018. Accessed: September 2021. Retrieved from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/760560/Decom_Guidance_Notes_November_2018.pdf

OSPAR 2021. OSPAR Guidelines for Completing the Harmonised Offshore Chemical Notification Format (HOCNF) (OSPAR Agreement: 2012-05. Update 2021). http://www.ospar.org/documents?v=33-43

Paige, R.W., L.R. Murray, J.P. Martins, and S.M. Marsh. 1995. "Optimising Water Injection Performance." Paper presented at the Middle East Oil Show, Bahrain, March 1995. doi: https://doi.org/10.2118/29774-MS

Tipura, Lejla, Tore Tjomsland, and Ann-Kristin Fagerbakke. 2013. "Increasing Oil Recovery on the Grane Field With Challenging PWRI." Paper presented at the OTC Brasil, Rio de Janeiro, Brazil, October 2013. doi: https://doi.org/10.4043/24532-MS

University of Guyana. 2019. "Approved Guidelines for the Appointment of Endowned Chairs, Professors of Practice and Distinguished Professorships." Presented and Approved by: Aug 28, 2019—Appointments Committee; June 17—Academic Board and Council in July 28, 2019. Accessed: September 2021. Retrieved from: https://www.uog.edu.gy/sites/default/files/documents/Approved%20Guidelines%20for%20the%20Appointment%20of%20Endowed%C2%A0Chairs%2C%20Professors%20of%20Practice%2C%20and%20Distinguished%C2%A0Professorships.pdf

WHO (World Health Organization). 2005. WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide—Global Update 2005.

World Bank. 2007. *Environmental, health, and safety general guidelines (English)*. IFC E&S. Washington, D.C.: World Bank Group. Accessed: July 2021. Retrieved from: https://documents1.worldbank.org/curated/en/157871484635724258/pdf/112110-WP-Final-General-EHS-Guidelines.pdf

_____. 2015. *Environmental, health, and safety guidelines for offshore oil and gas development (English)*. IFC E&S. Washington, D.C.: World Bank Group. Accessed: July 2021. Retrieved from: https://documents1.worldbank.org/curated/en/378221479466912449/pdf/110348-FINAL-Jun-2015-Offshore-Oil-and-Gas-EHS-Guideline-PUBLIC.pdf

Zuluaga, E., P. Evans, P. Nesom, T. Spratt, and E. Daniels. 2011. “Technical Evaluations To Support the Decision To Reinject Produced Water.” *SPE Prod & Oper* 26 (2011): 128–139. doi: https://doi.org/10.2118/132346-PA

Chapter 3 Administrative Framework

CARICOM (Caribbean Community). 2015. Caribbean Planning for Adaptation to Climate Change (CPACC) Project. Accessed: July 2021. Retrieved from: https://www.cpacc.org/

EITI (Extractive Industries Transparency Initiative). 2021. What We Do. Accessed: July 2021. Retrieved from: https://www.eiti.org/About

EPA (Guyana Environmental Protection Agency). 2018. Who We Are. Accessed: July 2021. Retrieved from: https://www.epaguyana.org/epa/about

_____. 2000. Integrated Coastal Zone Management Action Plan. Accessed: July 2021. Retrieved from: https://www.epaguyana.org/epa/component/jdownloads/summary/11-articles/76-05-10-integrated-coastal-zone-managemen-dc-cbt

Government of Guyana. 2001. Guyana Climate Change Action Plan: Actions for Addressing Climate Change. In Response to its Commitments to the UNFCC. June 2001. Accessed: July 2021. Retrieved from: https://unfccc.int/resource/docs/nap/guynap01.pdf

JNCC (Joint Nature Conservation Committee). 2017. JNCC Guidelines for Minimising the Risk of Injury to Marine Mammals from Geophysical Surveys. Accessed: July 2021. Retrieved from: https://data.jncc.gov.uk/data/e2a46de5-43d4-43f0-b296-c62134397ce4/jncc-guidelines-seismicsurvey-aug2017-web.pdf

Ministry of Natural Resources. 2021. *Local Content Policy for the Development of Guyana’s Petroleum Economy*. Revised draft, February 2021. Accessed: September 2021. Retrieved from: https://nre.gov.gy/2021/02/11/draft-local-content-policy-lcp/

Ministry of the Presidency. 2015. *Climate Resilience Strategy and Action Plan for Guyana*. Draft for Consultation, November 2015. Accessed: September 2021. Retrieved from: https://climatechange.gov.gy/en/index.php/resources/documents/124-climate-resilience-strategy-and-action-plan/file

Ministry of the Presidency and Department of Energy. 2020. *Guyana Petroleum Sector: Realising Local Content Benefits and Value Retention from Guyana's Petroleum Resources Local Content Policy*. January 2020. Accessed: September 2021. Retrieved from: https://op.gov.gy/wp-content/uploads/2020/02/local-content-benefits-new-use.pdf

Office of the President. 2016. Low Carbon Development Strategy. Accessed: July 2021. Retrieved from: https://www.lcds.gov.gy/index.php

Shah, Kalim. 2019. *National Climate Change Policy and Action Plan 2020–2030*. Daft 2.0, May 14, 2019. Developed by Dr. Kalim Shah, Consultant, on behalf of the Office for Climate Change, Ministry of the Presidency, Guyana. Accessed: September 2021. Retrieved from: https://climatechange.gov.gy/en/index.php/resources/documents/50-draft-national-climate-change-policy-and-action-plan-2020-2030/file

Chapter 4 Methodology for Preparing the Environmental Impact Assessment

EMC (Environmental Management Consultants Inc.). 2021. Participatory Fish Study: Quarterly Report April–June 2021.

ERM (Environmental Resources Management). 2018. Nearshore and Offshore Fisheries Study Report. Technical report to Guyana EPA.

EPA (Guyana Environmental Protection Agency). 2004. Volume 1 Environmental Impact Assessment Guidelines: Rules and Procedures for Conducting and Reviewing EIAs. Version 5. 34 pp.

EPA/EAB (Guyana Environmental Protection Agency/Environmental Advisory Assessment Board). 2000. Environmental Impact Assessment Guidelines. Volume 2-Generic. Version 4 November 2000. Environmental Protection Agency/Environmental Assessment Board.

Chapter 5 Scope of the Environmental Impact Assessment

Alt, R.C., and M.D. Zoback. 2016. In Situ Stress and Active Faulting in Oklahoma, *Bulletin of the Seismological Society of America*, 107, pp.: 216-228.

ANSI. 2013. *American National Standard: Quantities and Procedures for Descriptions and Measurement of Environmental Sound – Part 3: Short-term Measurements with and Observer Present*. Acoustical Society of America. Approved January 15, 2013. Accessed: October 2021. Retrieved from: https://webstore.ansi.org/standards/asa/ansiasas122013part-1452563

Badino, A., D. Borelli, T. Gaggero, E. Rizzuto, and C. Schenone. 2016. "Airborne noise emissions from ships: Experimental characterization of the source and propagation over land." *Applied Acoustics* 104 (2016) 158-171. DOI:10.1016/J.APACOUST.2015.11.005

Brink, U.S.T., and J. Lin. 2004. Stress Interaction between Subduction Earthquakes and Forearc Strike-slip Faults: Modeling and Application to the Northern Caribbean Plate Boundary. *Journal of Geophysical Research* B: Solid Earth. Accessed: July 2021. Retrieved from: https://doi.org/10.1029/2004JB003031

ERM (Environmental Resources Management). 2014. Strategic Environmental Assessment for Offshore Exploration Drilling Stabroek License Area, Guyana. Liza and Sorubim Areas of Interest. Prepared for Esso Exploration and Production Guyana Limited. March 2014.

_____. 2015. Strategic Environmental Assessment Addendum 1: Liza-2 Exploration Well. Prepared for Esso Exploration and Production Guyana Limited. October 2015.

_____. 2016. Environmental Management Plan: Multiwell Exploration Program. Prepared for Esso Exploration and Production Guyana Limited. April 2016.

_____. 2017. Environmental Impact Assessment for Liza Phase 1 Development Stabroek License Area, Guyana. Liza Project Area. Prepared for Esso Exploration and Production Guyana Limited. February 2017. Volumes I–IV.

_____. 2018a. Environmental Impact Assessment for Liza Phase 2 Development Project. Prepared for Esso Exploration and Production Guyana Limited. February 2017. Volumes I–III.

_____. 2018b. Environmental Management Plan Addendum. Prepared for Esso Exploration and Production Guyana Limited. June 2018.

_____. 2019. Environmental Management Plan: Stabroek Multiwell Exploration Program. Prepared for Esso Exploration and Production Guyana Limited. April 2019.

_____. 2020a. Environmental Assessment and Management Plan: Canje Block 3-Well Drilling Exploration Program. Prepared for Esso Exploration and Production Guyana Limited. February 2020.

_____. 2020b. Environmental Assessment and Management Plan: Kaieteur Block 1-Well Exploration Drilling Campaign. Prepared for Esso Exploration and Production Guyana Limited. April 2020.

_____.2020c. Environmental Impact Assessment: Payara Development Project. Prepared for Esso Exploration and Production Guyana Limited. July 2020.

Foulger, G.R, M.P. Wilson, J.G. Gluyas, B.R. Julian, and R.J. Davies. 2018. Global Review of Human-induced Earthquakes, *Earth Science Reviews*, 178: pp. 438-514.

Kundu, B., N.K. Vissa, and V.K. Gahalaut. 2015. Influence of Anthropogenic Groundwater Unloading in Indo-Gangetic Plains on the 25 April 2015 Mw 7.8 Gorkha, Nepal Earthquake, *Geophys. Res. Lett*., 42, pp. 10607-10613.

López-Venegas, A. M., S. E. Chacón-Barrantes, N. Zamora, and J. Macías. 2018. Nations work together to size up Caribbean tsunami hazards. *Eos*, 99. Published on 04 October 2018. Accessed: August 2021. Retrieved from: https://eos.org/science-updates/nations-work-together-to-size-up-caribbean-tsunami-hazards

Macías, J., M.J. Castro, S. Ortega, C. Escalante, and J.M. González-Vida. 2017. Performance benchmarking of Tsunami-HySEA model for NTHMP's inundation mapping activities. *Pure Appl. Geophys.*, 174: 3147–3183. Accessed: July 2021. Retrieved from: https://doi.org/10.1007/s00024-017-1583-1

Guardian Geomatics. 2020. Yellowtail Project Final Geophysical Report: Geophysical Development Survey – SE Stabroek Block Offshore. Prepared on behalf of Ocean Infinity. 09 November 2020.

UNISDR (United Nations International Strategy for Disaster Reduction). 2014. Prevention Web: Guyana Disaster & Risk Profile. Accessed: July 2021. Retrieved from: http://web.archive.org/web/20210525124623/https://www.preventionweb.net/countries/guy/data/

USGS (U.S. Geological Survey). 2010. Preliminary Seismic Hazard Model for South America. Accessed: July 2021. Retrieved from: https://prd-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/atoms/files/SAmer-Proceedings2010_1.pdf

WHOI (Woods Hole Oceanographic Institution). 2005. Major Caribbean Earthquakes and Tsunamis a Real Risk. Accessed: July 2021. Retrieved from: https://www.whoi.edu/press-room/news-release/major-caribbean-earthquakes-and-tsunamis-a-real-risk/

World Bank Group. 2019. ThinkHazard Tool: Identify Natural Hazards in your Project Area and Understand how to Reduce their Impact. Accessed: July 2021. Retrieved from: http://thinkhazard.org/en/report/107-guyana

Chapter 6 Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources

Section 6.1 Air Quality, Climate, and Climate Change

Carnegie Endowment for International Peace. Undated. COMPARE OILS: Saudi Arabia Ghawar v. S. America & Carribean. Accessed: July 2021. Retrieved from: http://oci.carnegieendowment.org/#compare/saudi-arabia-ghawar/s.-america-&-carribean

Climate Watch. Undated. Guyana. Accessed: July 2021. Retrieved from: https://www.climatewatchdata.org/countries/GUY

ERM (Environmental Resources Management). 2017. Environmental Impact Assessment for Liza Phase 1 Development Stabroek License Area, Guyana. Liza Project Area. Prepared for Esso Exploration and Production Guyana Limited. February 2017. Volumes I–IV.

_____.2020. Environmental Impact Assessment: Payara Development Project. Prepared for Esso Exploration and Production Guyana Limited. July 2020.

ERM, EMC, and GSEC (Environmental Resources Management, Environmental Management Consultants, and Ground Structures Engineering Consultants). 2018. Environmental Impact Assessment for Liza Phase 2 Development Project. Prepared for Esso Exploration and Production Guyana Limited. February 2017. Volumes I–III.

ExxonMobil. 2021. ExxonMobil announces corporate plans to 2027—supports approximately doubling earnings and cash flow potential, reducing emissions. 1 December 2021. Accessed: January 2022. Retrieved from: https://corporate.exxonmobil.com/News/Newsroom/News-releases/2021/1201_ExxonMobil-announces-plans-to-2027-doubling-earnings-and-cash-flow-potential-reducing-emissions

Garthwaite, Josie. 2018. “Measuring crude oil’s carbon footprint.” Stanford University, School of Earth, Energy, and Environmental Sciences. Accessed: July 2021. Retrieved from: https://earth.stanford.edu/news/measuring-crude-oils-carbon-footprint#gs.9w2fi0

GFDL (Geophysical Fluid Dynamics LaboratoryGFDL). Global Warming and Hurricanes: An Overview of Current Research Results. Last Revised 9 August 2021. Accessed: September 2021. Retrieved from: https://www.gfdl.noaa.gov/global-warming-and-hurricanes/

Government of Guyana. 2012. Second National Communication to the United Nations Framework Convention on Climate Change. Accessed: July 2021. Retrieved from: https://unfccc.int/resource/docs/natc/guync2.pdf

Guyana NDC. 2016. Guyana’s Revised Intended Nationally Determined Contribution. Submitted 20 May 2016. Accessed: July 2021. Retrieved from: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Guyana%20First/Guyana%27s%20revised%20NDC%20-%20Final.pdf

IPCC (Intergovernmental Panel on Climate Change). 2021. *Climate Change 2021: The Physical Science Basis*. 7 August 2021. Accessed: September 2021. Retrieved from: https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report_smaller.pdf

McSweeney, C., M. New, and G. Lizcano. 2010. UNDP Climate Change Country Profiles: Guyana. Accessed: July 2021. Retrieved from: http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/UNDP_reports/Guyana/Guyana.lowres.report.pdf

National Hurricane Center and Central Pacific Hurricane Center. Undated. Saffir-Simpson Hurricane Wind Scale. Accessed: December 2021. Retrieved from: https://www.nhc.noaa.gov/aboutsshws.php

NOAA (National Oceanic and Atmospheric Administration). 2008. *Currents*. U.S. Department of Commerce, National Oceanographic and Atmospheric Administration. Accessed: July 2021. Retrieved from: https://oceanservice.noaa.gov/education/tutorial_currents/welcome.html

OGCI (Oil and Gas Climate Initiative). Undated. OGCI's Upstream Carbon Intensity Target. Accessed: September 2021. Retrieved from: https://www.ogci.com/action-and-engagement/ogcis-upstream-carbon-intensity-target/

Perkins, Robert. 2020. "Oil majors say progress 'significant' on upstream methane, carbon intensity". S&P Global Platts. October 2020. Accessed: September 2021. Retrieved from: https://www.spglobal.com/platts/en/market-insights/latest-news/natural-gas/101920-oil-majors-say-progress-significant-on-upstream-methane-carbon-intensity.

Skamarock, W. C., J.B. Klemp, J. Dudhia, D.O. Gill, D.M. Barker, J. Berner, Zhiquan Liu, M.G. Duda, X-Y Huang, W. Wang, and J.G. Powers. 2019. A Description of the Advanced Research WRF Model Version 4. NCAR Technical Note, NCAR/TN-556+STR, March 2019.

UNDP (United Nations Development Programme). 2020. Technical Support towards the Preparation of Guyana's Second Nationally Determined Contribution to the Paris Agreement. Accessed: September 2020. Retrieved from: https://procurement-notices.undp.org/view_file.cfm?doc_id=228255

UNEP (United Nations Environment Programme). 2019. *Emissions Gap Report 2019*. UNEP, Nairobi. Accessed: July 2021. Retrieved from: https://wedocs.unep.org/bitstream/handle/20.500.11822/30797/EGR2019.pdf

USAID (United States Agency International DevelopmentUSAID). 2018. Fact Sheet Climate Risk Profile: Eastern and Southern Caribbean. February 2018. Accessed: September 2021. Retrieved from: https://www.climatelinks.org/sites/default/files/asset/document/2018-26-Feb_CadmusCISF_Climate-Risk-Profile-ES-Caribbean.pdf

USEPA (U.S. Environmental Protection Agency). Undated. Webpage with links to AP42: Compilation of Air Emissions Factors. Accessed: July 2021. Retrieved from: https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors

_____. 1999. Integrated Risk Information System. Accessed: July 2021. Retrieved from: https://www.epa.gov/iris

Vergara, W., A.R. Rios, L.M. Galindo, P. Gutman, P. Isbell, P.H. Suding, and J. Samaniego. 2013. *The Climate and Development Challenge for Latin America and the Caribbean: Options for climate-resilient, low-carbon development*. Inter-American Development Bank. Accessed: July 2021. Retrieved from: https://www.imf.org/external/np/seminars/eng/2013/caribbean/pdf/challenge.pdf

WHO (World Health Organization). 2000. WHO Air Quality Guidelines for Europe, 2nd edition.

_____. 2005. WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide—Global Update 2005.

_____. 2021. WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. World Health Organization. License: CC BY-NC-SA 3.0 IGO. Accessed: October 2021. Retrieved from: https://apps.who.int/iris/handle/10665/345329

WHO and UNFCCC (World Health Organization and United Nations Framework Convention on Climate Change. 2020. Guyana: Health & Climate Change Country Profile 2020. Accessed: September 2021. Retrieved from: https://cdn.who.int/media/docs/default-source/climate-change/who-unfccc-cch-country-profile-guyana.pdf?sfvrsn=7fd8e6db_2&download=true

WMO (World Meteorological Organization). 2021. State of the Climate in Latin America and the Caribbean: 2020. WMO-No. 1272. 2021. Accessed: September 2021. Retrieved from: https://reliefweb.int/sites/reliefweb.int/files/resources/1272_Statement_LAC_en_big.pdf

World Bank. 2016. World Bank Group to Deepen Engagement with Guyana. 3 May. Accessed: July 2021. Retrieved from: http://www.worldbank.org/en/news/press-release/2016/05/03/world-bank-group-deepen-engagement-guyana

World Weather & Climate Information. 2016. Climate: Average Monthly Weather in Georgetown, Guyana. Accessed: July 2021. Retrieved from: https://weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,Georgetown-gy,Guyana

WRI (World Resources Institute). Undated_a. Climate Watch Tool. Accessed: September 2021. Retrieved from: https://www.climatewatchdata.org/

_____. Undated_b. Climate Watch Tool: Historical GHG Emissions. Accessed: September 2021. Retrieved from: https://www.climatewatchdata.org/ghg-emissions?end_year=2018&start_year=1990

Section 6.2 Sound

Bradley, D.L., and R. Stern. 2008. *Underwater Sound and the Marine Mammal and Acoustic Environment: A Guide to Fundamental Principles*. July 2008. Prepared for the U.S. Marine Mammal Commission.

Haver, S.M., Adams, J.D., Hatch, L.T., Van Parijs, S.M., Dziak, R.P., Haxel, J., Heppel, S.A., McKenna, M.F., Mellinger, D.K., and Gedamke, J. 2021. “Large Vessel Activity and Low-Frequency Underwater Sound Benchmarks in United States Waters.” *Frontiers in Marine Science* 8:669528.

Hildebrand, J.A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. *Marine Ecology Progress Series*, 395: 5–20.

Hildebrand, J.A., Frasier, K.E., Baumann-Pickering, S., and Wiggins, S.M. 2021. “An empirical model for wind-generated ocean noise.” *Journal of the Acoustical Society of America*, 149 (6): 4516–4533.

JNCC (Joint Nature Conservation Committee). 2017. JNCC Guidelines for Minimising the Risk of Injury to Marine Mammals from Geophysical Surveys. Accessed: July 2017. Retrieved from: http://jncc.defra.gov.uk/pdf/jncc_guidelines_seismicsurvey_aug2017.pdf

McDonald, M., J. Hildebrand, S. Wiggins, and D. Ross. 2008. A 50 Year comparison of ambient ocean noise near San Clemente Island: A bathymetrically complex coastal region off Southern California. *J. Acoust. Soc. Am.*, 124(4).

University of Rhode Island and Inner Space Center. Undated. Discovery of Sound in the Sea, Hot Topic—Deep Ocean Sounds. Accessed: July 2021. Retrieved from: https://dosits.org/deep-ocean-sounds/

Wiggins, S.M., Hall, J.E., Thayre, B.J, and Hildebrand, J.A. 2016. “Gulf of Mexico low-frequency ocean soundscape impacted by airguns.” *Journal of the Acoustical Society of America*, 140 (1): 176–183.

Section 6.3 Marine Geology and Sediments

Bågander, L.E. 1978. An Evaluation of the Use of Redox Measurements for Characterizing Recent Sediments. *Estuarine and Coastal Marine Science*, 6: 127-134.

Bennett, R.H., H. Lee, and M.H. Hulbert. 1990. Water in Marine Sediments. Naval Oceanographic and Atmospheric Research Laboratory, Seafloor Geoscience Division, Stennis Space Center, MS.

Benthic USA LLC., 2019. Environmental Baseline Study Liza Phase 2 Field Development Guyana. A report for Esso Exploration and Production Guyana Ltd.

Buchman, M.F. 2008. NOAA Screening Quick Reference Tables, NOAA OR&R Report 08-1. Seattle, WA: Office of Response and Restoration Division, National Oceanic and Atmospheric Administration.

CGX (CGX Resources Inc.). 2009. Strategic Environmental Assessment for Offshore Exploration Drilling Corentyne License Area, Guyana. June 2009.

Clark, R.C., and M. Blumer. 1967. Distribution of n-Paraffins in Marine Organisms and Sediments. *Limnol Oceanography*, 12: 79–87.

ECASA (Ecosystem Approach to Sustainable Aquaculture). 2004. ECASA Toolbox: Sediment Redox Potential, Eh. L

Eisma, D., and H. van der Marel. 1971. Marine Muds along the Guyana Coast and their origin from the Amazon Basin. *Contrib. Mineral. Petrol.*, 31: 321–334.

Ellis, D.V., and C. Heim. 1985. Submersible Surveys of Benthos near a Turbidity Cloud. *Mar Poll Bull*, 16(5): 197–203.

Escobar-Briones, E., García-Villalobos F.J. 2009. Distribution of total organic carbon and total nitrogen in deep-sea sediments from the southwestern Gulf of Mexico. Boletín de la Sociedad Geológica Mexicana, 61 (1): 73-86.

ESL (Environmental Services Limited). 2018. Final Environmental Baseline Assessment of Sediment Quality along the continental Shelf, Guyana—Phase 2. April 2018

Fugro Atlantic. 2011. Seabed Scour Considerations for Offshore Wind Development on the Atlantic OCS. Prepared for the Bureau of Ocean Energy Management Regulation and Enforcement. FUGRO Project No. 3707.001. U.S. Department of the Interior. Herdnon, Virginia.

Fugro EMU Limited. 2016. Environmental Baseline Survey Report. Liza Development, Offshore Guyana. Prepared for Esso Exploration and Production Guyana Ltd. March 2016.

Fugro GM Marine Limited. 2016. Environmental Survey Report, Liza Development, Offshore Guyana. Fugro Report No. 2415-3066-EBS.

Fugro GB Marine Limited. 2019. Environmental Baseline Survey and Habitat Assessment Report: Payara Development, Offshore Guyana. Fugro Document No.: 1803-1430-V8-EBS. 6 March 2019.

Guardian Geomatics. 2020. Yellowtail Project. Final Geophysical Report. Prepared for Esso Exploration and Production Guyana Limited. GYYT-GP-GRZZZ-00-0001

IMO (International Maritime Organization). 2003. International Regulations (MARPOL 73/78). “Revised Guidelines and Specifications for Pollution Prevention Equipment for Machinery Space Bilges of Ships.” Annex 13. Resolution MEPC. 107(49). Adopted on 18 July 2003.

_____. 2018. Simplified overview of the discharge provisions of the revised MARPOL Annex V which entered into force on 1 March 2018. Accessed: March 2022. Retrieved from: https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Simplified%20overview%20of%20the%20discharge%20provisions%20of%20the%20revised%20MARPOL%20Annex%20V.pdf

Long, E.R., D.D. McDonald, S.L. Smith, and F.D. Calder. 1995. “Incidence of Adverse Biological Effects Within Range of Chemical Concentrations in Marine and Estuarine Sediments.” *Environmental Management.* 19(1): 81-97.

Macdonald, D.D., R.S. Carr, and F.D. Calder. 1996. Development and Evaluation of Sediment Quality Guidelines for Florida Coastal Waters. *Ecotoxicology*, 5: 253.

MarLIN (Marine Life Information Network). 2019. *MarESA pressures and benchmarks.* Accessed: August 2018. Retrieved from: https://www.marlin.ac.uk/sensitivity/SNCB-benchmarks

Maxon Consulting, Inc., and TDI-Brooks International, Inc. 2014. Environmental Baseline Study, Guyana Stabroek Block. Final Report. Prepared for Esso Exploration and Production Guyana Ltd. July 2014

Maxon Consulting, Inc., and TDI-Brooks International, Inc. 2019. Environmental Baseline Study, Stabroek Block, Offshore Guyana. Final Report. July 2019.

Maxon Consulting, Inc., TDI-Brooks International, Inc., and Benthic USA LLC. 2019. Environmental Baseline Study, Canje Block Offshore Guyana. Draft Report. Prepared for Esso Exploration and Production Guyana, Ltd. January 2019.

NDS (National Development Strategy). 1997. Guyana's National Development Strategy. Accessed: July 2021. Retrieved from: http://www.guyana.org/NDS/chap31.htm

North Sea Task Force. 1993. North Sea Subregion 8 Assessment Report. State Pollution Control Authority, (SFT): 1–79.

OGP (International Association of Oil & Gas Producers). 2003. "Environmental aspects of the use and disposal of non aqueous drilling fluids associated with offshore oil & gas operations." Report No. 342. May 2003.

Rowe, G.T., and M.C. Kennicutt II (eds.). 2009. Northern Gulf of Mexico continental slope habitats and benthic ecology study: Final Report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region. New Orleans, LA. OCS Study MMS 2009-039: 456.

Royal Haskoning, Delft Hydraulics. 2004. Institutional Capacity Building Activities on Guyana Sea Defences, Bathymetric Survey Report. Haskoning Nederland Bv, Reference 9M5198.21/RG019/FRW/Guy.

Schlesinger, W.H., and E. Bernhardt. 2013. Biogeochemistry: An Analysis of Global Change 3rd. Ed. Academic Press.

Sætersdal, G.; G. Bianchi; T. Strømme; S.C. Venema. 1999. The DR. FRIDTJOF NANSEN Programme 1975–1993. Investigations of fishery resources in developing countries. History of the programme and review of results. FAO Fisheries Technical Paper. No. 391. Rome, FAO. 1999: 434. Accessed: July 2021. Retrieved from: http://www.fao.org/3/X3950E/X3950E00.htm#TOC.

Salomons W, Förstner U. 1984. Metals in the Hydrocycle. Springer-Verlag, New York, NY. 349.

Shepard FP. 1954. "Nomenclature based on sand-silt-clay ratios." *Journal of Sedimentary Petrology*. 24:151-158.

TDI-Brooks (TDI-Brooks International, Inc.). 2014. Geotechnical Report Guyana Liza-Sorubim EBS & Geotechnical Investigation Offshore Guyana, South America.

Thompson, S., and G. Eglinton. 1978. The Fractionation of a Recent Sediment for Organic Geochemical Analysis. *Geochim. Cosmochim. Acta*. 42: 199–207.

Turekian KK, Wedepohl KH. 1961. "Distribution of the Elements in Some Major Units of the Earth's Crust." *Geological Society of American Bulletin*. 72: 175-192.

Wedepohl, K.H. 1995. The composition of the continental crust. *Geochimica et Cosmochimica Acta*. 79(7): 1217-1232.

World Bank. 2015. *Environmental, health, and safety guidelines for offshore oil and gas development (English)*. IFC E&S. Washington, D.C.: World Bank Group. Accessed: July 2021. Retrieved from: https://documents1.worldbank.org/curated/en/378221479466912449/pdf/110348-FINAL-Jun-2015-Offshore-Oil-and-Gas-EHS-Guideline-PUBLIC.pdf

Workman, W., and D.J. Birnie. 2015. The Guyana-Suriname Basin: Exploration Opportunity. Search and Discovery Article #10730, March 2015. Accessed: September 2021. Retrieved from: https://www.searchanddiscovery.com/pdfz/documents/2015/10730workman/ndx_workman.pdf.html

Workman, W.G. 2000. Special Report: Geophysics and Geology. Guyana Basin: A new exploration focus. WorldOil Online. 221(5). Accessed: July 2021. Retrieved from: http://www.worldoil.com/May-2000-Guyana-basin-A-new-exploration-focus.html

Youngblood, W.W., M. Blumer, R. Guilard, and R. Fiore. 1971. Saturated and Unsaturated Hydrocarbons in Marine Benthic Algae. *Mar. Biol*. 8(3): 130–201.

Zobell, C.E. 1946. Studies on Redox Potential of Marine Sediments. *Bulletin of the American Association of Petroleum Geologists.* 30: 477-511.

Section 6.4 Marine Water Quality

De Master, D.J., and R.H. Pope. 1996. “Nutrient Dynamics in Amazon Shelf Waters: Results from AMASSEDS.” *Cont. Shelf Res*. 16(3): 263–289.

ESL (Environmental Services Limited). 2018a. Final Environmental Baseline Sediment Quality Report for Exxon Guyana Project: Phase 2 Offshore Guyana. April 2018.

ESL (Environmental Services Limited). 2018b. Final Water Quality Report for Exxon Guyana Project: Phase 1 Offshore Guyana. January 2018.

FAO (Food and Agricultural Organization of the United Nations). 2005. Fishery Country Profile: The Republic of Guyana. Accessed: July 2021. Retrieved from: http://www.fao.org/fi/oldsite/FCP/en/GUY/profile.htm

Fugro EMU Limited. 2016. Environmental Baseline Survey Report. Liza Development, Offshore Guyana. Prepared for Esso Exploration and Production Guyana Ltd. March 2016.

Fugro. 2019a. Environmental Baseline Survey and Habitat Assessment Report: Payara Development, Offshore Guyana. Fugro Document No.: 1803-1430-V8-EBS. 6 March 2019.

Fugro GB Marine Limited. 2019b. Environmental Baseline Survey and Habitat Assessment Report. Continental Slope AUV Survey. Hammerhead Development, Offshore Guyana. Fugro Document No.: 1903-1507-V8-EBS.

Gyory, J., A.J. Mariano, and E.H. Ryan. 2013. The Guiana Current. Ocean Surface Currents. Accessed: July 2021. Retrieved from: http://oceancurrents.rsmas.miami.edu/atlantic/guiana.html

Hansell, D.A., and C.A. Carlson. 2001. “Marine dissolved organic matter and the carbon cycle.” *Oceanography*. 14(4):41-49.

IMO (International Maritime Organization). 2006. International Regulations (MARPOL 73/78). “Revised Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants.” Annex 26. Resolution MEPC. 159(55). Adopted on 13 October 2006. MEPC 55/23

_____. 2012. Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants. Annex 22. Resolution MEPC.227(64). Adopted on 5 October 2012. MEPC 64/23.

Maxon Consulting, Inc., TDI-Brooks International, Inc., and Benthic USA LLC. 2019. Environmental Baseline Study, Canje Block Offshore Guyana. Draft Report. Prepared for Esso Exploration and Production Guyana, Ltd. January 2019.

Maxon Consulting, Inc. and TDI-Brooks International, Inc. 2014. Environmental Baseline Study, Guyana Stabroek Block. Final Report. Prepared for Esso Exploration and Production Guyana Ltd. July 2014. Ref. 14024. 106 pp.

Nittrouer, C.A., and D.J. De Master. 1987. Sedimentary Processes on the Amazon Continental Shelf. New York: Pergamon Press.

RPS. 2016. Guyana Metocean Measurement Campaign, Guyana, South America. Final Data Reports prepared for Esso Exploration & Production Guyana Limited, North Cummingsburg, Georgetown, Guyana. Data Report 1, September 2016.

_____. 2017a. Guyana Metocean Measurement Campaign, Guyana, South America. Final Data Reports prepared for Esso Exploration & Production Guyana Limited, North Cummingsburg, Georgetown, Guyana. Data Report 2, March 2017.

_____. 2017b. Guyana Metocean Measurement Campaign, Guyana, South America. Final Data Reports prepared for Esso Exploration & Production Guyana Limited, North Cummingsburg, Georgetown, Guyana. Data Report 3, April 2017.

_____. 2017c. Guyana Metocean Measurement Campaign, Guyana, South America. Final Data Reports prepared for Esso Exploration & Production Guyana Limited, North Cummingsburg, Georgetown, Guyana. Data Report 4, November 2017.

_____. 2018a. Appendix A: Offshore Guyana Metocean Observations and Model Comparison Assessment. 2 April 2018.

_____. 2018b. Guyana Metocean Measurement Campaign Gayana, South America. Prepared for Esso Exploration & Production Guyana Limited. Data Report 5, July 2018.

Sarmiento, J., and N. Gruber. 2006. Ocean biogeochemical dynamics. Princeton University Press, Princeton, NJ.

Sherman, K., and G. Hempel. 2009. The UNEP Large Marine Ecosystem Report: A Perspective on Changing Conditions in LMEs of the World's Regional Seas. UNEP Regional Seas Report and Studies No. 182. 2nd printing. Nairobi, Kenya: United Nations Environment Programme.

Smedley, P.L., and D.G. Kinniburgh. 2017. "Molybdenum in natural waters: A review of occurrence, distributions and controls." *Applied Geochemistry* 84: 387-432.

TDI-Brooks International, Inc. 2014. Geotechnical Report Guyana Liza-Sorubim EBS & Geotechnical Investigation Offshore Guyana, South America.

USEPA (U.S. Environmental Protection Agency). 2017. The Npdes General Permit for New and Existing Sources and New Dischargers in the Offshore Subcategory of the Oil and Gas Extraction Point Source Category for the Western Portion of the Outer Continental Shelf of the Gulf of Mexico (GMG290000). Accessed: 30 August 2021. Retrieved from: https://www.epa.gov/sites/default/files/2017-09/documents/2017_final_gp_for_fr_091817.pdf

World Bank. 2015. *Environmental, Health, and Safety Guidelines for Offshore Oil and Gas Development (English)*. IFC E&S. Washington, D.C.: World Bank Group. Accessed: July 2021. Retrieved from: https://documents1.worldbank.org/curated/en/378221479466912449/pdf/110348-FINAL-Jun-2015-Offshore-Oil-and-Gas-EHS-Guideline-PUBLIC.pdf

Chapter 7 Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources

Section 7.1 Protected Areas and Special Status Species

Bovell, O. 2011. Guyana Mangrove Nursery Manual. Guyana Mangrove Restoration Project. Retrieved from: http://www.gcca.eu/sites/default/files/catherine.paul/guyana_mangrove_nursery_manual_2011.pdf

Charles, R., M. Bynoe, J. Wishart, and M. Cheong. 2004. Shell Beach Protected Area Situation Analysis. GMTCS publication.

Convention on Biological Diversity. 2015. Guyana's Fifth National Report to the Convention on Biological Diversity. Accessed: March 2020. Retrieved from: https://www.cbd.int/doc/world/gy/gy-nr-05-en.pdf

EPA et al. (Guyana Environmental Protection Agency et al.) 2004. Shell Beach Protected Area Rapid Biodiversity Assessment August-October 2004.

EPA and MoNRE (Guyana Environmental Protection Agency and Ministry of Natural Resources and the Environment). 2015. Guyana's National Biodiversity Strategy and Action Plan (2012 – 2020). Approved May 2015. 101 pp. Accessed: July 2021. Retrieved from: http://faolex.fao.org/docs/pdf/guy156992.pdf

ERM (Environmental Resources Management). 2018a. Coastal Bird Study Report 2017–2018. May 2018.

_____. 2018b. Marine Bird Study Report 2017–2018. May 2018.

_____. 2018c. Nearshore and Offshore Fisheries Study Summary Report 2017–2018. May 2018.

ESL (Environmental Services Limited). 2018. Final Environmental Baseline Assessment of Sediment Quality along the continental Shelf, Guyana—Phase 2. April 2018

Fugro EMU Limited. 2016. Environmental Baseline Survey Report. Liza Development, Offshore Guyana. Prepared for Esso Exploration and Production Guyana Ltd, March 2016. Fugro Job No. 2415-3066-EBS. 125 pp.

Fugro GB Marine Limited. 2019. Environmental Baseline Survey and Habitat Assessment Report: Payara Development, Offshore Guyana. Fugro Document No.: 1803-1430-V8-EBS. 6 March 2019.

GMTCS (Guyana Marine Turtle Conservation Society). 2011. Proposed Shell Beach Delineation Process, Final Report. University of Guyana. Pp.1–41.

Guyana Chronicle. 2014. “Guyana’s Protected Areas System.” Accessed: July 2021. Retrieved from: https://guyanachronicle.com/2014/05/10/guyanas-protected-areas-system/

IUCN (International Union for Conservation of Nature). 2012. IUCN Red List Categories and Criteria: Version 3.1. Second edition. IUCN: Gland, Switzerland and Cambridge, UK.

_____. 2021. Red List of Threatened Species Version 2021.1. Accessed: July 2021. Retrieved from: http://www.iucnredlist.org/

JNCC (Joint Nature Conservation Committee). 2017. JNCC Guidelines for Minimising the Risk of Injury to Marine Mammals from Geophysical Surveys. Accessed: July 2021. Retrieved from: http://jncc.defra.gov.uk/pdf/jncc_guidelines_seismicsurvey_aug2017.pdf

Kandaswamy, S.V. 2014. Shell Beach Management Plan. Volume 1 and 2. Protected Areas Commission.

Maxon Consulting, Inc. and TDI Brooks International, Inc. 2014. Environmental Baseline Study. Guyana Stabroek Block. Prepared for Esso Exploration and Production Guyana Ltd. July 2014. Ref. 14024. 106 pp.

NRL (National Red List). 2018. National Red List. Accessed: July 2021. Retrieved from: http://www.nationalredlist.org/library/national-red-lists-library/

PAC (Protected Areas Commission). 2014. Shell Beach Protected Area Management Plan 2015-2019. Volume 1 Final. December 15, 2014. 28pp.

Pritchard, P. 2001. Shell Beach as a Protected Area. Occasional Paper, Georgetown.

Protected Areas Trust (Guyana). 2021. Shell Beach Protected Area. Accessed: August 2021. Retrieved from: https://protectedareastrust.org.gy/protected-areas/shell-beach/#site-main

Section 7.2 Coastal Habitats

Allison, M., and T. Lee. 2004. “Sediment Exchange between Amazon Mud Banks and Shore Fringing Mangroves in French Guiana.” *Marine Geology* 208:169-190.

Anthony, E.J., A. Gardel, and N. Gratiot. 2013. Fluvial Sediment Supply, Mud Banks, Cheniers and the Morphodynamics of the Coast of South America between the Amazon and Orinoco River Mouths. *Geological Society, London, Special Publications*. Doi: 10.1144/SP 388.8.

Beckman, W.D. 2013. Marine Environmental Biology and Conservation—the Estuary and Marsh: Habitat Impacts and Environmental Protection. Jones & Bartlett Publishers, pp. 144-146.

Conservation International. 2018. Setting the Foundations for Zero Net Loss of the Mangroves that Underpin Human Wellbeing in the North Brazil Shelf LME (NBS-LME). Project ID 9949.

CPACC (Caribbean Planning for Adaptation to Global Climate Change Project). 2002. Guyana’s Coastal Vulnerability and Risk Assessment. Caribbean Community Climate Change Centre, Belmopan, Belize. Digital Edition.

Crooks, S., L. Beers, M. Mak, and C. May. 2019 North Brazil Shelf Mangrove Project: Regional Biophysical Review. Report by Conservation International and Silvestrum Climate Associates.

Da Silva, P. 2014. Avifaunal Diversity in a Mangrove Reserve in Guyana, South America. *International Journal of Science, Environment and Technology*, 3(1): 23–32.

_____. 2015. Mutual Benefits from Mangrove Reserves in Guyana: Coastal Protection and Avifaunal Habitats. *International Journal of Science, Environment*. 4(4): 924-933.

EPA and MoNRE (Guyana Environmental Protection Agency and Ministry of Natural Resources and the Environment). 2014. Guyana’s National Biodiversity Strategy and Action Plan (2012–2020). Approved May 2015. 101 pp. Accessed: July 2021. Retrieved from: http://extwprlegs1.fao.org/docs/pdf/guy156992.pdf

ERM (Environmental Resources Management). 2018a. Coastal Bird Study Report 2017–2018. May 2018.

_____. 2018b Enhanced Coastal Sensitivity Mapping—Biodiversity. Unpublished report to the Guyana EPA.

GAHEF (Guyana Agency for Health Sciences Education). 1992. Country Study of Biological Diversity (Draft). Liliendaal, Greater Georgetown, Guyana.

Ilieva. Undated. The Socioeconomic Importance of Mangroves in Guyana. Ecosystem Services Evaluation. Ca’Foscari University of Venice, Italy.

Kalamandeen, M., and P. Da Silva. 2002. “Preliminary Survey of the Herpetofauna of Lori Beach, Shell Beach, Guyana. May 27th–July 9th 2002.” In: *Biodiversity and Conservation Studies in Guyana: 1, 2, and 3*.

Mann, K. 1982. Ecology of Coastal Waters: a System Approach. Berkeley: University of California.

Mestre, L.A.M., R. Krul, and V.S. Moraes. 2007. Mangrove Bird Community of Paranaguá Bay - Paraná, Brazil. In: *Brazilian Archives of Biology and Technology*. 50(1): 75–83. Accessed: July 2021. Retrieved from: https://www.researchgate.net/publication/239281169_Mangrove_bird_community_of_Paranagua_Bay_-_Parana_Brazil/fulltext/027cf7dc0cf268dd53c92b95/239281169_Mangrove_bird_community_of_Paranagua_Bay_-_Parana_Brazil.pdf?origin=publication_detail

NAREI (National Agricultural Research and Extension Institute). 1996. Guyana: Country Report to The FAO International Technical Conference on Plant Genetic Resource, Leipzig, Germany. Compiled by National Agricultural Research Institute, Georgetown, May 1995.

Nedeco. 1968. Surinam Transporation Study: Report on Hydraulic Investigation. Netherlands Engineering Consultants. The Hague, 293 pp.

Pastakia, C. 1991. *A Preliminary Study of the Mangroves of Guyana*. Aquatic Biological Consultancy Services Limited.

Persaud, H. 2011. Spatio-Temporal Analysis of Guyana’s Coastal Zone (Study Site Region # 5—Mahaica–Berbice). Guyana Mangrove Restoration Project.

Reynaud, Pierre Adrien. 1990. Importance of Littoral Mudflats for Migrant and Resident Avifauna. Accessed: July 2021. Retrieved from: https://horizon.documentation.ird.fr/exl-doc/pleins_textes/pleins_textes_6/colloques2/37539.pdf

Saenger, P., E. Hegerl, and D. Davie. 1983. “Global Status of Mangrove Ecosystems.” *The Environmentalist*, (supplement no.3), pp. 88.

Toorman, E.A., E. Anthony, P.G.E.F.Augustinus, A. Gardel, N. Gratiot, O. Homenauth, N. Huybrechts, J. Monbaliu, K. Moseley, and S. Naipal. 2018. “Interaction of Mangroves, Coastal Hydrodynamics, and Morphodynamics Along the Coastal Fringes of the Guianas.” In C. Makowski and C.W. Finkl (Eds.). *Threats to Mangrove Forests*. 25: 429–473. Springer International Publishing. Accessed: July 2021. Retrieved from: https://doi.org/10.1007/978-3-319-73016-5_20

WWF (World Wildlife Fund). 2016. Eastern South America: Coastal French Guiana, Suriname, Guyana, and Southeastern Venezuela. Accessed: July 2021. Retrieved from: http://www.worldwildlife.org/ecoregions/nt1411

Section 7.3 Coastal Wildlife

Bayney, A., and P. Da Silva. 2005. "The Effect of Birding on Local and Migrant Waterfowl Populations Along the Coast of Guyana." *Contributions to the Study of Biological Diversity Vol. 2*. Centre for the Study of Biological Diversity, University of Guyana, Faculty of Natural Sciences. 3-18.

BirdLife International. 2016. Country Profile: Guyana. Accessed July 2021. Retrieved from: http://datazone.birdlife.org/country/guyana

Braun, M.J., D.W. Finch, M.B. Robbins, and B.K. Schmidt. 2007. *A Field Checklist of the Birds of Guyana, 2nd Ed*. Smithsonian Institution, Washington, D.C.

Da Silva, P. 2014. "Avifaunal Diversity in a Mangrove Reserve in Guyana, South America." *International Journal of Science, Environment and Technology*, 3(1): 23–32.

EPA et al. (Guyana Environmental Protection Agency et al.) 2004. Shell Beach Protected Area Rapid Biodiversity Assessment August-October 2004.

IUCN (International Union for Conservation of Nature). 2021. IUCN Red List of Threatened Species Version 2021-1. Accessed: July 2021. Retrieved from: http://www.iucnredlist.org/

Mendonca, S., M. Kalamandeen, and R.S. McCall. 2006. "A Bird's Eye View: Coastal Birds of Shell Beach." Proceedings of International Conference on the Status of Biological Sciences in Caribbean and Latin American Societies.

Olson, D.M., E. Dinerstein, E.D. Wikramanayake, N.D. Burgess, G.V.N. Powell, E. C. Underwood, J.A. D'Amico, I. Itoua, H.E. Strand, J.C. Morrison, C.J. Loucks, T.F. Allnutt, T.H. Ricketts, Y. Kura, J.F. Lamoreux, W.W. Wettengel, P. Hedao, and K.R. Kassem. 2001. Terrestrial Ecoregions of the World: A New Map of Life on Earth. *BioScience,* 51(11):933-938.

Section 7.4 Seabirds

Alves, J., M. Dias, and V. Méndez et al. 2016. "Very rapid long-distance sea crossing by a migratory bird." *Sci Rep* 6, 38154 (2016). https://doi.org/10.1038/srep38154

Baird, P.H. 1990. Concentrations of Seabirds at Oil-drilling Rigs. *Condor*, 92: 768–771.

Birdlife International. 2021a. BirdLife International Data Zone Country Profile for Guyana. Accessed: July 2021. Retrieved from: http://datazone.birdlife.org/species/results?cty=92&cri=&fam=0&gen=0&spc=&cmn=&bt=&rec=N&vag=N&stsea=Y&wat=&aze=

_____. 2021b. Marine IBA e-Atlas. Accessed: July 2021. Retrieved from: https://maps.birdlife.org/marineibas/

_____. 2021c. Country Profile: Trinidad and Tobago. Accessed: July 2021. Retrieved from: http://www.birdlife.org/datazone/country/trinidad-and-tobago.

_____. 2021d. Country Profile: Venezuela. Accessed: July 2021. Retrieved from: http://www.birdlife.org/datazone/country/venezuela.

Braun, M.J., D.W. Finch, M.B. Robbins, and B.K. Schmidt. 2007. A Field Checklist of the Birds of Guyana, 2nd Ed. Smithsonian Institution, Washington, D.C.

Deda, P., I. Elbertzhagen, and M. Klussmann. 2007. Light Pollution and the Impacts on Biodiversity, Species and their Habitats. In C. Marín and J. Jafari (eds.) Starlight – A common heritage. Starlight Initiative, Instituto de Astrofísica de Canarias (IAC), La Palma, Canary Islands, Spain, 19-20 April 2007.

Deppe JL, MP Ward, RT Bolus, RH Diehl, A Celis-Murillo, TJ Zenzal, FR Moore, TJ Benson, JA Smolinsky, LN Schofield, and DA Enstrom DA. 2015. “Fat, weather, and date affect migratory songbirds’ departure decisions, routes, and time it takes to cross the Gulf of Mexico.” *Proc Natl Acad Sci* 112:E6331–E6338. doi:10.1073/pnas.1503381112

eBird. 2021a. eBird Country List for Guyana. Accessed: July 2021. Retrieved from: https://ebird .org/country/GY?yr=cur

_____. 2021b. Black-capped Petrel: *Pterodroma hasitata*. Accessed: July 2021. Retrieved from: https://ebird.org/species/bkcpet

Fabi, G., F. Grati, A. Lucchetti, and L. Trovarelli. 2002. “Evolution of the fish assemblage around a gas platform in the northern Adriatic Sea. *ICES Journal of Marine Science*. Volume 59, Issue suppl, 2002, Pages S309–S315.

Gaston, K.J., J. Bennie, T.W. Davies, and J. Hopkins. 2013. The Ecological Impacts of Nighttime Light Pollution: a Mechanistic Appraisal. *Biol Rev*, 88: 912–927.

Hunt, George L. Jr., and Robert W. Furness. 1996. Seabird/Fish Interactions with Particular Reference to Seabirds in the North Sea. *ICES Journal of Marine Science*. Report No. 216, Pages 1-87

IUCN (International Union for Conservation of Nature). 2021. IUCN Red List of Threatened Species Version 2021-1. Accessed: July 2021. Retrieved from: http://www.iucnredlist.org/

Jodice, P.G.R., R.A. Ronconi, E. Rupp, G.E. Wallace, and Y. Satgé. 2015. First Satellite Tracks of the Endangered Black-capped Petrel. *Endangered Species Research* 29: 23–33.

Marquenie, J. 2007. Green Light to Birds: Investigation into the Effect of Bird-Friendly Lighting. Accessed: July 2021. Retrieved from: http://www.waddenzee.nl/fileadmin/content/ Dossiers/Energie/pdf/green_light_to_birdsNAM.pdf

McGrady, M.J., G.S. Young, and W.S. Seegar. 2006. Migration of a Peregrine Falcon (*Falco peregrinus*) over Water in Vicinity of a Hurricane. *Ringing and Migration.* 23(2): 80-84.

Montevecchi, W.A. 2006. Ecological consequences of artificial light on marine birds. Island Press. Washington DC, Pages 94-113.

Platteeuw, M., and R. Henkens. 1997. Possible Impacts of Disturbance to Waterbirds: Individuals, Carrying Capacity, and Populations. *Wildfowl*, 48: 225–236.

Ronconi, R.A., K.A. Allard, and P.D. Taylor. 2015. Bird Interactions with Offshore Oil and Gas Platforms: Review of Impacts and Monitoring Techniques. *Journal of Environmental Management*. 147: 34–45. Accessed: July 2021. Retrieved from: https://www.sciencedirect.com/science/article/pii/S0301479714003806?via%3Dihub

RPS. 2018. Protected Species Observer Summary. ExxonMobil Guyana 2015–2018.

_____. 2019. Protected Species Observer Summary. ExxonMobil Guyana May 2018–2019

_____. 2020a. Protected Species Observer Report: ExxonMobil Hammerhead Geotechnical Survey. 16 March 2020.

_____. 2020b. Protected Species Observer Report: ExxonMobil Hammerhead Geotechnical Survey.

_____. 2020c. ExxonMobil Multi AUV Geophysical Survey. Seabed Constructor and Normand Frontier. 22 July 2020.

_____. 2020d. Protected Species Observer Report: ExxonMobil Geotechnical and Geophysical Survey Nearshore Survey. 1 December 2020

_____. 2020e. Protected Species Observer Final Report: ExxonMobil Bulletwood—1 VSP. 18 December 2020.

_____. 2021. Protected Species Observer Final Report: ExxonMobil SC VSP. May 2021.

Schreiber, E. 2001. Biology of Marine Birds. Edited by E.I. Schreiber and Johanna Burger. CRC Press. 740 pp.

Simons, T.R., D.S. Lee, and J.C. Haney. 2013. *Diablotin Pterodroma hasitata*: a Biography of the Endangered Black-capped Petrel. *Marine Ornithology.* 41: 3-43.

Wiese, F.K., W.A. Montevecchi, G.K. Davoren, F. Huettmann, and A.W. Diamond. 2001. Seabirds at Risk around Offshore Oil Platforms in the North-west Atlantic. *Marine Pollution Bulletin*. 42: 1285–1290.

Section 7.5 Marine Mammals

Amano, M., and M. Yoshioka. 2003. Sperm Whale Diving Behavior Monitored Using a Suction-cup-attached TDR Tag. *Mar. Ecol. Prog. Ser*. 258: 291−295.

BOEM (Bureau of Ocean Energy Management). 2014. Programmatic Environmental Impact Statement for Atlantic OCS Proposed Geological and Geophysical Activities in the Mid-Atlantic and South Atlantic Planning Areas. U.S. Department of the Interior. Gulf of Mexico OCS Region.

Bolaños-Jiménez, J., L. Bermúdez-Villapol, A. Sayegh, and G. Sole. 2006. Current Status of Small Cetaceans in Venezuela. SC/58/SM9. Presented to the Scientific Committee. 58th Annual Meeting of the International Whaling Commission. St. Kitts & Nevis.

Finneran, J.J. 2015. Auditory Weighting Functions and TTS/PTS Exposure Functions for Cetaceans and Marine Carnivores. San Diego: SSC Pacific.

Charles, R., M. Bynoe, J. Wishart, and M. Cheong. 2004. Shell Beach Protected Area Situation Analysis. GMTCS publication.

Clark, R.A., C.M. Johnson, G. Johnson, R. Payne, I. Kerr, R.C. Anderson, S.A. Sattar, C.J. Godard, and P.T. Madsen. 2012. Cetacean Sightings and Acoustic Detections in the Offshore Waters of the Maldives during the Northeast Monsoon Seasons of 2003 and 2004. *Journal of Cetacean Research and Management.* 12(2): 227-234.

de Boer, M.N. 2010. Cetacean Distribution and Relative Abundance in Offshore Gabonese Waters. *Journal of the Marine Biological Association of the United Kingdom.* 90(8): 1613-1621. Accessed: July 2021. Retrieved from: http://dx.doi.org/10.1017/S002531541 0001165

_____. 2015. Cetaceans observed in Suriname and adjacent waters. *Latin American Journal of Aquatic Mammals.* 10(1): 2-19. Accessed: July 2021. Retrieved from: http://dx.doi.org/ 10.5597/lajam00189

Fugro Marine GeoServices Inc. 2017. Geophysical and Geotechnical Investigation Methodology Assessment for Siting Renewable Energy Facilities on the Atlantic OCS. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs, Herndon. OCS Study BOEM 2017-049. Accessed: September 2021. Retrieved from: https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Renewable-Energy/G-and-G-Methodology-Renewable-Energy-Facilities-on-the-Atlantic-OCS.pdf

Gannier, A., D. Violaine, and J.C. Goold. 2002. “Distribution and relative abundance of sperm whales in the Mediterranean Sea.” Marine Ecology Progress Series, vol. 243: 281-293, 2002. Published 13 November.

Hildebrand, J.A. 2005. “Impacts of Anthropogenic Sound” in *Marine Mammal Research: Conservation beyond Crisis*. Edited by J.E. Reynolds III, W.F. Perrin, R.R. Reeves, S. Montgomery, and T.J. Ragen. The Johns Hopkins University Press, Baltimore, Maryland. Pp. 101-124. Accessed: August 2021. Retrieved from: https://escholarship.org/content/qt8997q8wj/qt8997q8wj.pdf

IUCN (International Union for Conservation of Nature). 2021. IUCN Red List of Threatened Species Version 2021-1. Accessed: July 2021. Retrieved from: http://www.iucnredlist.org/

JASCO (JASCO Applied Sciences). 2016. Underwater Sound Associated with Liza Phase 1 Project Activities.

JNCC (Joint Nature Conservation Committee). 2017. JNCC Guidelines for Minimising the Risk of Injury to Marine Mammals from Geophysical Surveys. Accessed: July 2021. Retrieved from: http://jncc.defra.gov.uk/pdf/jncc_guidelines_seismicsurvey_aug2017.pdf

Koschinski, Sven and Karin Lüdemann. 2020. Noise mitigation for the construction of increasingly large offshore wind turbines Technical options for complying with noise limits. Commissioned by the Federal Agency for Nature Conservation (Bundesamt für Naturschutz, BfN). Acessed: September 28. Retrieved from: https://www.bfn.de/fileadmin/BfN/meeresundkuestenschutz/Dokumente/Noise-mitigation-for-the-construction-of-increasingly-large-offshore-wind-turbines.pdf

Mannocci, L., R. Monestiez, J. Bolaños, G. Doremus, S. Jérémie, S. Laran, R. Rinaldi, O. Van Canneyt, and V. Ridoux. 2013. Megavertebrate Communities from Two Contrasting Ecosystems in the Western Tropical Atlantic. *Journal of Marine Systems*, 111: 208–222. Accessed: July 2021. Retrieved from: http://dx.doi.org/10.1016/j.jmarsys.2012.11.002

Mate, B. Undated. GPS/TDR Satellite Tracking of Sperm Whales with 3-axis Accelerometers. Oregon State University, Hatfield Marine Science Center, Newport, OR 97365-5296.

Minasian, S.M., K.C. Balcomb, and L. Foster. 1984. The Worlds Whales: The Complete Illustrated Guide. Smithsonian Books, 224 pp.

MMS and NOAA (Minerals Management Service and National Oceanic and Atmospheric Administration National Marine Fisheries Service). 2007. Seismic Surveys in the Beaufort and Chukchi Seas, Alaska. Draft Programmatic Environmental Impact Statement. Accessed: August 2021. Retrieved from: https://www.boem.gov/about-boem/seismic-surveys-beaufort-and-chukchi-seas-alaska

NOAA (National Oceanic and Atmospheric Administration). Undated. Marine Mammals and Noise Fact Sheet. NOAA Fisheries Service Southeast Region. Accessed: July 2021. Retrieved from: http://sero.nmfs.noaa.gov/protected_resources/outreach_and_education/documents/marinemammalsandnoisefactsheet2016.pdf

_____. 2013. Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammals. 23 December 2013.

OSHA (Occupational Safety and Health Administration). 2013. OSHA Technical Manual. Section III, Chapter 5: Noise. Accessed: July 2021. Retrieved from: https://www.osha.gov/dts/osta/otm/new_noise/#hearingloss

Project GloBAL. 2007. Global Bycatch Assessment of Long Lived Species. Country Profile, Guyana. Blue Ocean Institute and WIDECAST. 17pp.

Ridoux, V., G. Certain, G. Doremus, S. Laran, O. van Canneyt, and P. Watremez. 2010. Mapping Diversity and Relative Density of Cetaceans and Other Pelagic Megafauna across the Tropics: General Design and Progress of the REMMOA Aerial Surveys Conducted in the French EEZ and Adjacent Waters. Paper SC/62/E14 presented to the Scientific Committee, 62nd Annual Meeting of the International Whaling Commission.

RPS. 2018. Protected Species Observer Summary. ExxonMobil Guyana 2015-2018.

_____. 2019. Protected Species Observer Summary. Prepared for ExxonMobil 2018-2019.

_____. 2019. ExxonMobil Offshore Guyana, Payara Prospect. 18-P-201703. Oil Spill Risk Assessment. 27 April 2019.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, Jr., D. Kastak, D.R. Ketten, and J.H. Miller. 2007. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. *Aquatic Mammals*. 33(4): 411–521.

Verfuss, U.K., R.R. Sinclair, and C.E. Sparling. 2019. A review of noise abatement systems for offshore wind farm construction noise, and the potential for their application in Scottish waters. Scottish Natural Heritage Research Report No. 1070. Accessed: September 2021. Retrieved from: https:// www.nature.scot/sites/default/files/2019-07/Publication%202019%20-%20SNH%20Research%20Report%201070%20-%20A%20review%20of%20noise%20abatement%20systems%20for%20offshore%20wind%20farm%20construction%20noise%2C%20and%20the%20potential%20for%20their%20application%20in%20Scottish%20waters.pdf

Ward, N., A. Moscrop, and C. Carlson. 2001. Elements for the Development of a Marine Mammal Action Plan for the Wider Caribbean: a Review of Marine Mammal Distribution.

Ward, N., and A. Moscrop. 1999. Marine Mammals of the Wider Caribbean Region: a Preliminary Review of their Conservation Status.

Watwood, S.L., P.J.O. Miller, M. Johnson, P.T. Madsen, and P.L. Tyack. 2006. Deep-diving Foraging Behavior of Sperm Whales (*Physeter macrocephalus*). *J. Anim. Ecol.* 75: 814−825.

Section 7.6 Riverine Mammals

Azevedo, A.F., Carvalho, R.R., Kajin, M., Van Sluys, M., Bisi, T.L., Cunha, H.A. and Lailson Brito Jr, J. 2017. The first confirmed decline of s delphinid population in Brazilian waters: 2000 - 2015 abundance of Sotalia guianensis in Guanabara Bay, South-eastern Brazil. Ecological Indicators 79: 1-10.

Banguera-Hinestroza, E., H. Cárdenas, M. Ruíz-García, M. Marmontel, E. Gaitán, R. Vásquez and F. García-Vallejo. 2002. Molecular identification of evolutionarily significant units in the Amazon River dolphin Inia sp. (Cetacea: Iniidae). Journal of Heredity 93: 9– 19.

Bertram, G.C.L., and C.K. Ricardo Bertram. 1960. In Search of Mermaids: The Manatees of the Guianas. Cambridge. Accessed: July 2021. Retrieved from: www.car-spaw-rac.org/IMG/pdf/The_status_of_manatees_in_the_Guianas.pdf

Best, R.C. and V.M.F. da Silva. 1989. Biology, status and conservation of *Inia geoffrensis* in the Amazon and Orinoco basins. In: W.F. Perrin, R.L. Brownell Jr., Zhou Kaiya and Liu Jiankang (eds) *Biology and Conservation of the River Dolphins*, pp. 23–34. IUCN/SSC Occasional Paper No. 3, Gland, Switzerland.

_____. 1989a. Amazon River dolphin, boto Inia geoffrensis (de Blainville, 1817). In: S.H. Ridgway and R. Harrison (eds), Handbook of marine mammals, Vol. 4: River dolphins and the larger toothed whales, pp. 1-24. Academic Press.

_____. 1989b. Biology, status and conservation of Inia geoffrensis in the Amazon and Orinoco river basins. In: W. F. Perrin, R. L. Brownell, K. Zhou and Lu Jiankang (eds), Biology and conservation of the river dolphins, pp. 23-34. IUCN Species Survival Commission.

Bertonatti, C. and A. Parera. 1994. Lobito de río. Revista Vida Silvestre, Nuestro Libra Rojo. Fundación Vida Silvestre Argentina, Ficha 34: 2.

Boher, S., J. Bolaños and L. J. Cova. 1995. Sobre un avistamiento del delfín estuarino o bufete (Sotalia fluviatilis) en el Orinoco Medio. Acta Científica Venezolana 46: 217– 218.

Bonvicino, C. R., Viana, M. C., Oliveira, E. H.C, Emin-Lima, R., Silva Júnior, J.S., Sousa & S. Siciliano, M. 2020. Distribution of South American manatees, Trichechus manatus Linnaeus, 1758 and T. inunguis (Natterer, 1883) (Sirenia: Trichechidae). Boletim do Museu Paraense Emílio Goeldi. Ciências Naturais 15(3): 573-599. DOI: http://doi.org/10.46357/bcnaturais.v15i3.246.

Borobia, M., S. Siciliano, L. Lodi and W. Hoek. 1991. Distribution of the South American dolphin Sotalia fluviatilis. Canadian Journal of Zoology 69: 1025– 1039.

Charles, R., M. Bynoe, J. Wishart, and M. Cheong. 2004. Shell Beach Protected Area Situation Analysis. GMTCS publication

Chehebar, C. 1990. Action plan for Latin American otters. IUCN/SSC Otter Specialist Group, Gland, Switzerland.

Cockrum, E.L. 1964. Southern river otter, Lutra annectens, from Sonora, Mexico. Journal of Mammalogy 45: 634-635.

Cromwell, L. Personal communication. 2021. The Guyana Wildlife Conservation and Management Commission (GWCMC). August 9, 2021.

Culik, B. M. 2004. Review of small cetaceans: Distribution, behaviour, migration and threats. Marine Mammal Action Plan/Regional Seas Reports and Studies 177: 343 pp.

da Silva, V.M.F. and R.C. Best. 1996. Sotalia fluviatilis. Mammalian Species 527: 1-7.

_____. 1994. Tucuxi *Sotalia fluviatilis* (Gervais, 1853). In: S. H. Ridgway and R. Harrison (eds), *Handbook of marine mammals, Volume 5 The first book of dolphins*, pp. 43-69. Academic Press, London, UK.

_____. 1996. Sotalia fluviatilis. Mammalian Species 527: 1– 7.

da Silva, V., F. Trujillo, A. Martin, A.N. Zerbini, E. Crespo, E. Aliaga-Rossel, and R. Reeves. 2018. Amazon River Dolphin: *Inia geoffrensis*. The IUCN Red List of Threatened Species 2018: e.T10831A50358152. Accessed: July 2021. Retrieved from: http://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T10831A50358152.en

De Jesus Lobo, A., L.L. Wedekin, T. Sobral-Souza, and Y. Le Pendu. 2021. Potential distribution of Guiana dolphin (*Sotalia guianensis*): a coastal-estuarine and tropical habitat specialist. Journal of Mammology 102(1): 308-318.

de Souza L.S., J.S. Armbruster, and P.W. Willink. 2020. “Connectivity of Neotropical River Basins in the Central Guiana Shield Based on Fish Distributions.” *Frontiers in Forests and Global Change*. https://doi.org/10.3389/ffgc.2020.00008

Deutsch, C.J., C. Self-Sullivan, and A. Mignucci-Giannoni. 2008. Trichechus manatus. The IUCN Red List of Threatened Species: e.T22103A9356917. Accessed: July 2021. Retrieved from: http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T22103A9356917.en

Domning, D., and L.C. Hayek. 1986. “Interspecific and Intraspecific Morphological Variation in Manatees (Sirenia: *Trichechus*).” *Marine Mammal Science*. Volume 2, Issue 2. April 1986. Accessed: July 2021. Retrieved from: https://doi.org/10.1111/j.1748-7692.1986.tb00034.x

Duplaix, N. 1980. Observations of the ecology and behaviour of the giant river otter Pteronura brasiliensis in Suriname. Revue d’Ecologie (La Terre et La Vie) 34: 495-620.

_____. 2004. Guyana Giant Otter Project, 2002-2004 Research Results. Report to the Oceanic Society, San Francisco, CA.

Emmons, L.H., and F. Feer. 1990. Neotropical Rainforest Mammals: a Field Guide. University of Chicago Press, Chicago, USA and London, UK.

Fish, F.E. 1994. Influence of Hydrodynamic-design and Propulsive Mode on Mammalian Swimming Energetics. *Aust. J. Zool*. 42: 79–101.

Flores, P.A.C., and V.M.F. da Silva. 2009. Tucuxi and Guiana Dolphin - Sotalia fluviatilis and S. guianensis. In: Perrin, W. F., Würsig, B., and Thewissen, J. G. M (eds), Encyclopedia of marine mammals, Academic Press, Amsterdam.

Flores, P.A.C. and Bazzalo, M. 2004. Home ranges and movements patterns of the marine tucuxi Sotalia fluviatilis in Baía Norte, southern Brazil. Latin American Journal of Aquatic Mammals 3(1): 37-52.

Franco-de-Sá, J.F.O., Rosas, F. C. W., and E. Feldberg. 2007. *Cytogenetic study of the giant otter Pteronura brasiliensis Zimmermann 1780 (Carnivora, Mustelidae, Lutrinae)*. Genetics and Molecular Biology, 30(4), 1093–1096. doi:10.1590/s1415-47572007000600011

Gallo, J.P. 1991. The status and distribution of river otters (Lutra longicaudis annectens Major, 1897), in Mexico. Habitat 6: 5742.

Groenendijk, J., N. Duplaix, M. Marmontel, P. Van Damme, and C. Schenck. 2015. Giant Otter: *Pteronura brasiliensis*. The IUCN Red List of Threatened Species 2015: e.T18711A21938411. Accessed: July 2021. Retrieved from: http://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T18711A21938411.en

IUCN (International Union for Conservation of Nature). 2021. 2021 Red List of Threatened Species Version 2021-1. Accessed: July 2021. Retrieved from: http://www.iucnredlist.org/

IWC (International Whaling Commission). 2007. Report of the Sub-Committee on Small Cetaceans. Journal of Cetacean Research and Management 9: 297-325

_____. 2001. Report of the Standing Sub-Committee on Small Cetaceans. *Journal of Cetacean Research and Management*. 3: 263-291.

Laidler, P.E.1984. The behavioural ecology of giant otter in Guyana. Ph.D. thesis. University of Cambridge, UK. 296 pp

Larivière, S. 1999. “Lontra longicaudis.” *Mammalian Species.* 609: 1-5.

Martin, A.R., V.M.F. da Silva, V.M.F. and D.L. Salmon. 2004. “Riverine habitat preferences of botos (*Inia geoffrensis*) and tucuxis (*Sotalia fluviatilis*) in the Central Amazon.” *Marine Mammal Science* 20: 189-200.

McTurk, Diane, and Lucy H. Spelman. 2005. "Hand-Rearing and Rehabilitation of Orphaned Wild Giant Otters, Pterona brasiliensis, on the Rupununi River, Guyana, South America." *Zoo Biology*. 24:153–167.

Melquist, W.E. 1984. Status survey of otters (lutrinae) and spotted cates (Felidae) in Latin America. Completion Report, Contract no. 9006, IUCN. College of Forestry, Wildlife, and Range Sciences, University of Idaho, 269 pp.

Muanis, M.C., and L.F.B. Oliveira. 2011. Habitat Use and Food Niche Overlap by Neotropical Otter, Lontra longicaudis, and Giant Otter, Pteronura brasiliensis, in the Pantanal Wetland, Brazil. Proceedings of XIth International Otter Colloquium, IUCN Otter Specialist Group Bulletin 28(A): 76-85.

Noonan, P., S. Prout, & V. Hayssen. 2017. *Pteronura brasiliensis (Carnivora: Mustelidae). Mammalian Species*, 49(953), 97–108. doi:10.1093/mspecies/sex012

Parc Zoologique de Paris. 2021. Conservation Programme for Manatees. Accessed: August 7, 2021. Retrieved frome: https://www.parczoologiquedeparis.fr/en/conservation-research/conservation-programmes/conservation-programme-manatees

Redford, K.H. and J.F. Eisenberg. 1992. Mammals of the Neotropics, The Southern Cone: Chile, Argentina, Uruguay, Paraguay. University of Chicago Press, Chicago, USA.

Rheingantz, M. L., de Menezes, J. F. S. & de Thoisy, B. 2014. Defining Neotropical Otter Lontra Longicaudis Distribution, Conservation Priorities and Ecological Frontiers. Tropical Conservation Science, 7(2), 214–229. https://doi.org/10.1177/194008291400700204

Rheingantz, M.L., and C.S. Trinca. 2015. Neotropical Otter: *Lontra longicaudis*. The IUCN Red List of Threatened Species 2015: e.T12304A21937379. Accessed: July 2021. Retrieved from: http://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T12304A21937379.en

Roopsind, Indreanee. 2019. Pers. Comm. between Indreanee Roopsind Guyanaese Otter Specialist) and Julia Tims (ERM). 17 June 2019.

Secretariat of the Convention on Biological Diversity. 2014. Ecologically or Biologically Significant Marine Areas (EBSAs): Special places in the world's oceans. Volume 2: Wider Caribbean and Western Mid-Atlantic Region. 86 pages. Accessed: July 2021. Retrieved from: https://www.cbd.int/marine/ebsa/booklet-02-wcar-en.pdf

Soldateli, M., and C. Blacher. 1996. Consideracoes preliminares sobre o numero e distribuicao espaco/temporal de sinais de Lutra longicaudis (Olfers, 1818) (Carnivora: Mustelidae) nas lagoas da Conceicao e do Peri, Ilha de Santa Catarina, SC, Brasil. *Biotemas*. 9: 38-64. Accessed: July 2021. Retrieved from: https://periodicos.ufsc.br/index.php/biotemas/article/viewFile/22028/19968

Trujillo, F., Crespo, E., Van Damme, P.A., and Usma, J.S. (Eds). 2010. The Action Plan for South American River Dolphins 2010 – 2020. WWF, Fundación Omacha, WDS, WDCS, Solamac. Bogotá, D.C., Colombia.

Trujillo, F., C. García and J. M. Avila. 2000. Status and conservation of the tucuxi *Sotalia fluviatilis* (Gervais, 1853): Marine and fluvial ecotypes in Colombia. Report to the Scientific Committee of the International Whaling Commission, Adelaide, Australia, SC/52/SM11. 12 pp.

UNEP (United Nations Environment Programme). 2010. Regional Management Plan for the West Indian Manatee (*Trichechus manatus*) compiled by Ester Quintana-Rizzo and John Reynolds III. CEP Technical Report No. 48. UNEP Caribbean Environment Programme, Kingston, Jamaica. Accessed: July 2021. Retrieved from: https://www.fws.gov/caribbean/pdf/manateemanagementplan.pdf

Van Bressem, M.F., Santos, M.C.O. and Oshima, J.E.F. 2009. Skin diseases in Guiana dolphins (Sotalia guianensis) from the Paranaguá estuary, Brazil: A possible indicator of a compromised marine environment. Marine Environmental Research 67: 63-68.

Williams, R., Moore, J.E., Gomez-Salazar, C., Trujillo, F. and Burt, L. 2016. Searching for trends in river dolphin abundance: Designing surveys for looming threats, and evidence for opposing trends of two species in the Colombian Amazon. *Biological Conservation* 195: 136-145.

WWF (World Wildlife Fund). 2019. Amazon River Dolphin Fact Sheet. Accessed: July 2021. Retrieved from: https://www.worldwildlife.org/species/amazon-river-dolphin

_____. Undated. South American River Dolphin Initiative Strategy 2020-2030. Accessed: September 2021. Retrieved from: https://www.riverdolphins.org/wp-content/uploads/2021/07/Pub_SARDI_Strategy_2020-2030_ING.pdf

Section 7.7 Marine Turtles

Abreu-Grobois, A., and P. Plotkin. 2008. *Lepidochelys olivacea*. The IUCN Red List of Threatened Species 2008: e.T11534A3292503. IUCN SSC Marine Turtle Specialist Group. Accessed: July 2021. Retrieved from: https://www.iucnredlist.org/species/11534/3292503

Alvarez-Varas, R., R. Berzins, K. Bilo, J. Chevalier, C. Damien, B. Thoisy, A. Fallabrino, M. Garcia Cruz, S. Kelez, M. Lopez-Mendilharsu, M. Marcovaldi, R. Mast, C. Medrano, C. Miranda, M. A. Nalovic, L. Prosdocimi, J. M. Rguez-Baron, A. Santos, L. Soares, and G. Velez-Rubio. 2016. “Sea Turtles of South America.” In: *States of the World’s Sea Turtles*. SWOT. Accessed: July 2021. Retrieved from: https://www.researchgate.net/publication/298068843_Sea_Turtles_of_South_America

Bartol, S.M., and J.A. Musick. 2003. Sensory Biology of Sea Turtles. In: Lutz, P.L. et al. The biology of sea turtles, volume 2. *CRC Marine Biology Series*: pp. 79-102.

Bjorndal, K.A. 1997. Foraging Ecology and Nutrition of Sea Turtles. In: P.L. Lutz and J.A. Musick (eds.). The Biology of Sea Turtles, 1. CRC Press, Boca Raton, Florida, p 199−231.

Bjorndal, K.A., and J.B.C. Jackson. 2003. Roles of Sea Turtles in Marine Ecosystems: Reconstructing the Past. In: P. Lutz, J.A. Musick, and J. Wyneken (eds.). The Biology of Sea Turtles. Vol. 2. CRC Press; 2003. p. 259–273.

Bond, E., and M. James. 2017. “Pre-nesting Movements of Leatherback Sea Turtles, Dermochelys coriacea, in the Western Atlantic.” *Frontiers in Marine Science* 4, no. 223: 1-10.

Bradley, David L. and Richard Stern. 2008. *Underwater Sound and the Marine Mammal and Acoustic Environment: A Guide to Fundamental Principles*. July 2008. Prepared for the U.S. Marine Mammal Commission.

Dass, R. 2011. *Dermochelys coriacea* (Leatherback Turtle). The Online Guide to the Animals of Trinidad and Tobago. University of West Indies. Accessed: July 2021. Retrieved from: https://sta.uwi.edu/fst/lifesciences/sites/default/files/lifesciences/documents/ogatt/Dermochelys_coriacea%20-%20Leatherback%20Turtle.pdf

Dow, W., K. Eckert, M. Palmer, and P. Kramer. 2007. An Atlas of Sea Turtle Nesting Habitat for the Wider Caribbean Region. WIDECAST Technical Report No. 6. pp. 272.

Duarte, D., M. Broadhurst, and L. Dumont. 2019. “Challenges in Adopting Turtle Excluder Devices (TEDs) in Brazilian Penaeid Trawl Fisheries.” *Marine Policy* 99: 374-381.

Eckert, K.L. 1999. Designing a Conservation Program. In: K.L. Eckert et al. (eds.). Research and Management Techniques for the Conservation of Sea Turtles. IUCN/SSC Marine Turtle Specialist Group Publication, 4: pp. 6–8.

Eckert, K.L., and F. A. Abreu Grobois, eds. 2001. Proceedings of the Regional Meeting: “Marine Turtle Conservation in the Wider Caribbean Region: A Dialogue for Effective Regional Management.” Santo Domingo, 16-18 November 1999. WIDECAST, IUCN-MTSG, WWF, and UNEP-CEP.

Eckert, S.A., D. Bagley, S. Kubis, L.M. Ehrhart, C. Johnson, K. Stewart, and D. DeFreese. 2006. "Internesting and postnesting movements and foraging habitats of leatherback sea turtles (*Dermochelys coriacea*) nesting in Florida." *Chelonian Conservation and Biology* 5(2): 239-248. Accessed: July 2021. Retrieved from: https://doi.org/10.2744/1071-8443(2006)5[239:IAPMAF]2.0.CO;2

Fossette, S., C. Girard, M. Lo´pez-Mendilaharsu, P. Miller, A. Domingo., D. Evans, L. Kelly, V. Plot, L. Prosdocimi, S. Verhage, P. Gaspar, and J-Y. Georges. 2010. Atlantic Leatherback Migratory Paths and Temporary Residence Areas. PLoS ONE 5, no. 11: e13908. doi:10.1371/journal.pone.0013908

Fossette, S., L. Kelle, M. Girondot, E. Goverse, M.L. Hilterman, B. Verhage, B. Thosiy, and J. Georges. 2008. "The World's Largest Leatherback Rookeries: A Review of Conservation-oriented Research in French Guiana/Suriname and Gabon." *Journal of Experimental Marine Biology and Ecology.* 356: 69-82.

Fossette S., M.J. Witt, P. Miller, M.A. Nalovic, D. Albared, A.P. Almeida, A.C. Broderick, D. Chacón-Chaverri, M.S. Coyne, A. Domingo, S. Eckert, D. Evans, A. Fallabrino, S. Ferraroli, A. Formia, B. Giffoni, G.C. Hays, G. Hughes, L. Kelle, A. Leslie, M. López-Mendilaharsu, P. Luschi, L. Prosdocimi, S. Rodriguez-Heredia, A. Turney, S. Verhage, and B.J. Godley. 2014. "Pan-Atlantic Analysis of the Overlap of a Highly Migratory Species, the Leatherback Turtle, with Pelagic Longline Fisheries." *Proceedings pf the Royal Society B* 281: 20133065. Accessed: July 2021. Retrieved from: doi.org/10.1098/rspb.2013.3065

Godley, B.J., E.H.S.M. Lima, S. Åkesson, A.C. Broderick, F. Glen, M.H. Godfrey, P. Luschi, and G.C. Hays. 2003. "Movement patterns of green turtles in Brazilian coastal waters described by satellite tracking and flipper tagging." *Marine Ecology Progress Series* 253 (May). Accessed: July 2021. Retrieved from: https://doi.org/10.3354/meps253279

Guimares, S., Tavares, D., and C. Monteiro-Neto. 2017. "Incidental Capture of Sea Turtles by Industrial Bottom Trawl Fishery in the Tropical South-Western Atlantic." *Journal of the Marine Biological Associated of the United Kingdom.* 98(6): 1520-1531.

Hildebrand, J.A. 2005. "Impacts of Anthropogenic Sound" in *Marine Mammal Research: Conservation beyond Crisis*. Edited by J.E. Reynolds III, W.F. Perrin, R.R. Reeves, S. Montgomery, and T.J. Ragen. The Johns Hopkins University Press, Baltimore, Maryland. Pages 101-124. Accessed: August 2021. Retrieved from: https://escholarship.org/content/qt8997q8wj/qt8997q8wj.pdf

Houghton, J.D.R., T.K. Doyle, J. Davenport, R.P. Wilson, and G.C. Hays. 2008. "The role of infrequent and extraordinary deep dives in leatherback turtles (*Dermochelys coriacea*)." *Journal of Experimental Biology* 2008 211: 2566-2575; doi: 10.1242/jeb.020065

IUCN (International Union for Conservation of Nature). 2021. 2021 Red List of Threatened Species Version 2019.1. Accessed: June 2021. Retrieved from: http://www.iucnredlist.org/

Jackson, J.B.C. 2001. What was Natural in the Coastal Oceans? Proceedings of the National Academy of Sciences, USA 98: 5,411–5,418.

James, M.C., C.A. Ottensmeyer, and R.A. Myers. 2005. “Identification of high-use habitat and threats to leatherback sea turtles in northern waters: new directions for conservation.” *Ecology Letters* 8, no. 2 (February): 195–201. Accessed: July 2021. Retrieved from: https://doi.org/10.1111/j.1461-0248.2004.00710.x

James, M.C., S.A. Sherril-Mix, K. Martin, and R.A. Myers. 2006. “Canadian Waters Provide Critical Foraging Habitat for Leatherback Sea Turtles.” *Biological Conservation* 133(3): 347–357. Accessed: July 2021. Retrieved from: https://doi.org/10.1016/j.biocon.2006.06.012

_____. 2007. “Population Characteristics and Seasonal Migrations of Leatherback Sea Turtles at High Latitudes.” *Marine Ecology Progress Series* 337 (May): 245–254. Accessed: July 2021.Retrieved from: www.jstor.org/stable/24871021

JNCC (Joint Nature Conservation Committee). 2017. JNCC Guidelines for Minimising the Risk of Injury to Marine Mammals from Geophysical Surveys. Accessed: July 2021. Retrieved from: http://jncc.defra.gov.uk/pdf/jncc_guidelines_seismicsurvey_aug2017.pdf

Lagueux, C.J., C.L Campbell, and S. Strindberg. 2014. “Artisanal Green Turtle, Chelonia mydas, Fishery of Caribbean Nicaragua: I. Catch Rates and Trends, 1991–2011.” *PLoS ONE* 9, no.4: e94667. doi:10.1371/journal.pone.0094667

López-Mendilaharsu, M., C.F.D. Rocha, P. Miller, A. Domingo, and B. Wallace. 2008. Prolonged, Deep Dives by the Leatherback Turtle Dermochelys coriacea: Pushing their Aerobic Dive Limits. *JMBA2- Biodiversity Records*. Accessed: July 2021. Retrieved from: http://www.seaturtle.org/PDF/Lopez-MendilaharsuM_2009_JMBA2.pdf

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000a. “Marine Seismic Surveys—A Study of Environmental Implications.” *APPEA J* 40: 692–706.

McCauley, R.D, J. Fewtrell, A.J. Duncan, C. Jenner, M.N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000b. Marine Seismic Surveys: Analysis and Propagation of Air-Gun Signals; and Effects of Air-Gun Exposure on Humpback Whales, Sea Turtles, Fishes and Squid. Centre for Marine Science and Technology, Curtin University of Technology. August 2000. Accessed: July 2021. Retrieved from: https://cmst.curtin.edu.au/wp-content/uploads/sites/4/2016/05/McCauley-et-al-Seismic-effects-2000.pdf

McClellan, C.M., and A.J. Read. 2007. “Complexity and Variation in Loggerhead Sea Turtle Life History.” *Biology Letters* 3, no. 6. doi:10.1098/rsbl.2007.0355

_____. 2009. “Confronting the Gauntlet: Understanding Incidental Capture of Green Turtles through Fine-Scale Movement Studies.” *Endangered Species Research* 10: 165-179. doi:10.3354/esr00199

McClellan, C.M., A.J. Read, B.A. Price, W.M. Cluse, and M.H. Godfrey. 2009. “Using Telemetry to Mitigate the Bycatch of Long-Lived Marine Vertebrates.” *Ecological Applications* 19, no. 6: 1660-1671. doi:10.1890/08-1091.1

McClellan, C.M., J. Braun-McNeill, L. Avens, and B.P. Wallace. 2010. “Stable Isotopes Confirm a Dichotomy in Juvenile Loggerhead Sea Turtles.” *Journal of Experimental Marine Biology and Ecology* 387, no. 1:44-51. doi:10.1016/j.jembe.2010.02.020

Mortimer, J.A., and M. Donnelly. 2008. *Eretmochelys imbricata*. The IUCN Red List of Threatened Species 2008: e.T8005A12881238. IUCN SSC Marine Turtle Specialist Group. Accessed: July 2021. Retrieved from: https://www.iucnredlist.org/species/8005/12881238

Naro-Maciel, E., J.H. Becker, E.H.S.M. Lima, M.A. Marcovaldi, and R. DeSalle. 2007. “Testing Dispersal Hypotheses in Foraging Green Sea Turtles (Chelonia mydas) of Brazil” *Journal of Heredity* 98, no. 1 (January): 29–39. Accessed: July 2021. Retrieved from: https://doi.org/10.1093/jhered/esl050

Nelms, S., W. Piniak, C. Weir, and B. Godley. 2016. “Seismic Surveys and Marine Turtles: An Underestimated Global Threat.” *Biological Conservation.* 193: 49-65.

NMFS and USFWS (National Marine Fisheries Service and U.S Fish and Wildlife Service). 2007. Proceedings of the 14th Annual Symposium on Sea Turtle Biology and Conservation. 1-5 March 1994. Hilton Head, South Carolina, USA. National Marine Fisheries Service, Southeast Fisheries Science Center. NOAA Technical Memorandum NMFS-SEFSC-351.

NOAA Fisheries. 2014. Hawksbill Turtle (*Eretmochelys imbricata*). Accessed: July 2021. Retrieved from: https://www.fisheries.noaa.gov/species/hawksbill-turtle

_____. 2019. “Green Turtle.” Accessed: July 2021. Retrieved from: https://www.fisheries.noaa.gov/species/green-turtle

Northwest Atlantic Leatherback Working Group. 2018. Northwest Atlantic Leatherback Turtle (Dermochelys coriacea) Status Assessment (Bryan Wallace and Karen Eckert, Compilers and Editors). Conservation Science Partners and the Wider Caribbean Sea Turtle Conservation Network (WIDECAST). WIDECAST Technical Report No. 16. Godfrey, Illinois. 36 pp.

_____. 2019. Status Update. Modern Threats Taking a Toll on the Northwest Atlantic Leatherbacks. SWOT Report 14: 34-35.

PAC (Protected Areas Commission). 2014. Shell Beach Protected Area Management Plan 2015-2019. Accessed: May 2018. Retrieved from: http://nre.gov.gy/wp-content/uploads/2016/05/Protected-Area-Mgmt-Plan-Shell-Beach.pdf

Piniak, W.D., and K.L. Eckert. 2011. Sea Turtle Nesting Habitat in the Wider Caribbean Region. Endang. Species Res., 15: 129–141.

Piniak, W.E.D., S.A. Eckert, C.A. Harms, and E.M. Stringer. 2012. Underwater Hearing Sensitivity of the Leatherback Sea Turtle (Dermochelys Coriacea): Assessing the Potential Effect of Anthropogenic Noise. U.S. Department of the Interior, Bureau of Ocean Energy Management, Headquarters, Herndon, Virginia. OCS Study BOEM 2012-01156.

Pritchard, P.C.H. 1973. International Migrations of South American Sea Turtles (Cheloniidae and Dermochelidae). *Animal Behavior*, 21: 18–27.

_____. 1986. Sea Turtles in Guyana. Florida Audubon Society. Unpublished Manuscript.

Project GloBAL. 2007. Global Bycatch Assessment of Long Lived Species. Country Profile, Guyana. Blue Ocean Institute and WIDECAST. 17 pp.

Putman, N., and K. Mansfield. 2015. Direct Evidence of Swimming Demonstrates Active Dispersal in the Sea Turtle "Lost Years". *Current Biology*. CB. 25. 10.1016/j.cub.2015.03.014. Accessed: July 2021. Retrieved from: https://www .researchgate.net/publication/274901133_Direct_Evidence_of_Swimming_Demonstrate s_Active_Dispersal_in_the_Sea_Turtle_Lost_Years

Reich, K.L., K.A. Bjorndal, A.B Bolten. 2007. The "Lost Years" of Green Turtles: using Stable Isotopes to Study Cryptic Lifestages. *Biology Letters.* 3: 712-714.

Reichart, H., L. Kelle, L. Laurent, H.L. van de Lande, R. Archer, R. Charles, and R. Lieveld. 2003. Regional Sea Turtle Conservation Program and Action Plan for the Guianas (K.L. Eckert and M. Fontaine, Eds). World Wildlife Fund – Guianas Forests and Environmental Conservation Project, Paramaribo. WWF technical report no. GFECP#10. 85 pp. Accessed: July 2021. Retrieved from: http://ufdc.ufl.edu/AA00012423/00001

RPS. 2018. Results from Oil Spill Trajectory and Fate Modeling – Phase II Offshore Guyana. Project Number 2018-022095. 6 April 2018.

Sea Turtle Conservancy. 2012. Sea Turtle Tracking: Satellite Tracking of Marine Turtles in the Guianas. Accessed: July 2021. Retrieved from: https://www.conserveturtles.org/sea-turtle-tracking-satellite-tracking-of-marine-turtles-in-the-guianas/

Shillinger, G.L., A.M. Swithenbank, S.J. Bograd, H. Bailey, M.R. Castelton, B.P. Wallace, J.R. Spotila, F.V. Paladino, R. Piedra, and B.A. Block. 2010. Identification of High-Use Internesting Habitats for Eastern Pacific Leatherback Turtles: Role of the Environment and Implications for Conservation." *Endangered Species Research* 10:215–232.

Stewart, K.R., E.L. LaCasella, S.E. Roden, M.P. Jensen, L.W. Stokes, S.P. Epperly, and P.H. Dutton. 2016. "Nesting population origins of leatherback turtles caught as bycatch in the US pelagic longline fishery." *Ecosphere* 7(3): e01272. Accessed: July 2021. Retrieved from: https://doi.org/10.1002/ecs2.1272

Tambiah, C.R. 1994. Saving Sea Turtles or Killing Them: the Case of U.S. Regulated TEDs in Guyana and Suriname. Pages 149-151 in K.A. Bjorndal, A.B. Bolten, D.A. Johnson, and P.J. Eliazar, compilers. Proceedings of the 14th annual symposium on sea turtle biology and conservation. U.S. Department of Commerce, National Oceanic and Atmospheric Administration Technical Memorandum NMFSSEFSC-351. Miami, Florida.

Thums, M., S.D. Whiting, J. Reisser, K.L. Pendoley, C.B. Pattiaratchi, M. Proietti, Y. Hetzel, R. Fisher, and M.G. Meekan. 2016. “Artificial light on water attracts turtle hatchlings during their near shore transit.” *Royal Society Open Science*, Volume 3, Issue 5. 1 May 2016. Accessed: July 2021. Retrieved from: https://doi.org/10.1098/rsos.160142

Troëng, S., D. Chacon, and B. Dick. 2004. Possible Decline Leatherback Turtle *Dermochelys coriacea* Nesting in Caribbean Central America. *Oryx*. 38: 1–9.

Troëng, S., P.H. Dutton, and D. Evans. 2005. Migration of Hawksbill Turtles *Eretmochelys imbricata* from Tortuguero, Costa Rica. *Ecography*. 28: 394–402.

USFWS (U.S. Fish and Wildlife Service). 2018. Factsheet on Green Sea Turtles (*Chelonia mydas*). Accessed: July 2021. Retrieved from: https://www.fws.gov/north florida/seaturtles/turtle%20factsheets/green-sea-turtle.htm

Wallace, B., R. Lewison, S. McDonald, R. McDonald, C. Kot, S. Kelez, R. Bjorkland, E. Finkbeiner, S. Helmbrecht, and L. Crowder. 2010. “Global Patterns of Marine Turtle Bycatch.” *Conservation Letters.* 3(3): 131-142.

Witherington, B.E., and E. Martin. 2003. Understanding, Assessing, and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches. Fl. *Mar. Res. Inst. Tech. Rep*. TR-2.

Zbinden, J.A., Aebischer, A., Margaritoulis, D. et al. 2008. “Important areas at sea for adult loggerhead sea turtles in the Mediterranean Sea: satellite tracking corroborates findings from potentially biased sources.” Mar Biol 153: 899. Accessed: July 2021. Retrieved from: https://doi.org/10.1007/s00227-007-0862-2

Section 7.8 Marine Fish

Amoser, S., and F. Ladich. 2005. Are Hearing Sensitivities of Freshwater Fish Adapted to the Ambient Noise in their Habitats? *Journal of Experimental Biology* 2005 208: 3533-3542; doi: 10.1242/jeb.01809

Andree, SR, and DH Wahl. 2019. Effects of turbidity on foraging of juvenile black and white crappies. *Ecol Freshw Fish*. Vol. 28, Pages 123–131, Accessed: July 2021. Retrieved from: https://doi.org/10.1111/eff.12436

Barnthouse, L.W. 2013. Impacts of Entrainment and Impingement on Fish Populations: A Review of the Scientific Evidence. *Environmental Science & Policy*, 31: 149–156. August 2013.

Becker, A., A.K. Whitfield, P.D. Cowley, J. Järnegren, and T.F. Næsje. 2012. Potential Effects of Artificial Light Associated with Anthropogenic Infrastructure on the Abundance and Foraging Behaviour of Estuary Associated Fishes. *Journal of Applied Ecology*. Volume 50, Issue 1.

BOEM (Bureau of Ocean Energy Management). 2014. Programmatic Environmental Impact Statement for Atlantic OCS Proposed Geological and Geophysical Activities in the Mid-Atlantic and South Atlantic Planning Areas. U.S. Department of the Interior. Gulf of Mexico OCS Region.

CRFM (Caribbean Regional Fisheries Mechanism). Undated. Sargassum Seaweed Invasion: What, Why, and What We Can Do? Accessed: July 2021. Retrieved from: https://www.crfm.net/index.php?option=com_k2&view=item&id=449:sargassum-seaweed-invasion-what-why-and-what-we-can-do&Itemid=244&highlight=WyJzYXJnYXNzdW0gc2Vhd2VlZCBpbnZhc2lvbiJd

Donelson, J.M., M.I. McCormick, D.J. Booth, and P.L. Munday. 2014. Reproductive Acclimation to Increased Water Temperature in a Tropical Reef Fish. *PLoS One*, 9(5): e97223.

ERM (Environmental Resources Management). 2018. Nearshore and Offshore Fisheries Study Summary Report 2017–2018. Liza Phase 1 Development Project. Prepared for Esso Exploration and Production Guyana Limited. May 2018.

European Communities. 2007. European Union Risk Assessment Report: Sodium Hypochloride. European Communities Risk Assessment. CAS No: 7681-52-9, EINECS No. 231-668-3. Final Report, November 2007. Accessed: July 2021. Retrieved from: https://echa.europa.eu/documents/10162/330fee6d-3220-4db1-add3-3df9bbc2e5e5

Fugro. 2019. Desktop Study Analysis of Hard Seafloor Features. Payara and Liza Developments, Offshore Guyana. Fugro Document No.: 1901-1538-HSFDTS. 24 May 2019.

FWC (Florida Wildlife Commission). 2018. Lionfish-*Petrois volitans*. Accessed: July 2021. Retrieved from: http://myfwc.com/wildlifehabitats/nonnatives/marine-species/lionfish/

Grebe, C., L. Smith, and C. Reid. 2009. “The effects of marine seismic acquisition in a coral reef environment: results from a multi-disciplinary monitoring program at Scott Reef, Western Australia.” *The APPEA Journal* 49, 567-567. Accessed: July 2021. Retrieved from: https://doi.org/10.1071/AJ08040

Hastings, R.W., L.H. Ogren, and M.T. Mabry. 1976. Observations on the Fish Fauna Associated with Offshore Platforms in the Northeastern Gulf of Mexico. *US Natl Mar Fish Serv Fish Bull*, 74: 387–402.

Keenan, S.F., M.C. Benfield, and J.K. Blackburn. 2007. Importance of the Artificial Light Field Around Offshore Petroleum Platforms for the Associate Fish Community. *Marine Ecology Progress Series*. 331: 219–231. 2007.

Kegley, S.E., B.R. Hill, S. Orme, and A.H. Choi. 2016. PAN Pesticide Database, Pesticide Action Network, North America. Accessed: July 2021. Retrieved from: http://www.pesticideinfo.org

Kolman, M.A., A.A. Elbassiouny, E.A. Liverpool, and N.R. Lovejoy. 2017. DNA Barcoding Reveals the Diversity of Sharks in Guyana Coastal Markets. *Neotropical Ichthyology*, 15(4): e170097

Lindquist D., R. Shaw, F. Hernandez. 2005. Distribution Patterns of Larval and Juvenile Fishes at Offshore Petroleum Platforms in the North-central Gulf of Mexico. *Estuar Coast Shelf Sci*. 62: 655–665.

Lowe-McConnell, R.H. 1962. The Fishes of the British Guiana Continental Shelf, Atlantic Coast of South America, with Notes on Their Natural History. *J. Linn. Soc. Lond.* (Zool.). 44: 669-700.

Martinez-Andrade, F., and D.M. Baltz. 2003. Marine and Coastal Fishes Subject to Impingement by Cooling-Water Intake Systems in the Northern Gulf of Mexico: An Annotated Bibliography. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-040. 113 pp.

Meekan, M.G.; Speed, C.W.; McCauley, R.D.; Fisher, R.; Birt, M.J.; Currey-Randall, L.M.; Semmens, J.M.; Newman, S.J.; Cure, K.; Stowar, M.; Vaughan, B.; and M. J. G. Parsons. A large-scale experiment finds no evidence that a seismic survey impacts a demersal fish fauna. A large-scale experiment finds no evidence that a seismic survey impacts a demersal fish fauna | PNAS

MOA (Guyana Ministry of Agriculture, Fisheries Department). 2013. Marine Fisheries Management Plan 2013-2018.

NOAA (National Oceanic and Atmospheric Administration). 2020. Why are Lionfish a Growing Problem in the Atlantic Ocean? Accessed: July 2021. Retrieved from: https://oceanservice.noaa.gov/facts/lionfish.html

Palandro. 2016. Persistence of Sargassum in Guyana EEZ and Stabroek Lease Block. ExxonMobil Upstream Research Company.

Pankhurst, N.W., and P.L. Munday. 2011. Effects of Climate Change on Fish Reproduction and Early Life History Stages. *Marine and Freshwater Research*, 62: 1,015–1,026.

Slotte, A., K. Hansen, J. Dalen, E. Ona. 2004. Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. *Fisheries Research.* 67:143–150.

Stanley, D. R., and C.A. Wilson. 1991. Factors affecting the abundance of selected fishes near oil and gas platforms in the northern Gulf of Mexico. *Fishery Bulletin*. 89:149–159.

Stanley, D.R., and C.A. Wilson. 1997. Seasonal and Spatial Variation in the Abundance and Size Distribution of Fishes Associated with a Petroleum Platform in the Northern Gulf of Mexico. *Can. J. Fish. Aquat. Sci.* 54: 1166–1176.

Svobodová, Z., R. Lloyd, J. Máchová, and B. Vykusová. 1993. Water quality and fish health: Chapter 3 Causes and Effects of Pollution on Fish. EIFAC Technical Paper. No. 54. Rome, FAO. Pages 1-59.

USGS (U.S. Geological Survey). 2021. NAS-Nonindigenous Aquatic Species *Pterois volitans*/miles. Accessed: July 2021. Retrieved from: https://nas.er.usgs.gov/queries/SpeciesAnimatedMap.aspx?speciesID=963

Wardle, C.S., T.J. Carter, G.G. Urquhart, A.D.F. Johnstone, A.M. Ziolkowski, G. Hampson, and D. Mackie. 2001. “Effects of Seismic Air Guns on Marine Fish.” *Continental Shelf Research.* 21: 1005-1027. Accessed: July 2021. Retrieved from: https://www .scribd.com/document/311350234/Wardle-Et-Al-2001-Effects-of-Seismic-Air-Guns-on-Marine-Fish

WaterReUse. 2011. Desalination Plant Intakes: Impingement and Entrainment Impacts and Solutions. Revised June 2011. Accessed: July 2021. Retrieved from: https://www 3.epa.gov/region1/npdes/schillerstation/pdfs/AR-026.pdf

Wysocki, L.E., and F. Ladich. 2005. Hearing in Fishes under Noise Conditions. *Journal of the Association for Research in Otolaryngology* 6: 28. Accessed: July 2021. Retrieved from: https://doi.org/10.1007/s10162-004-4043-4

Section 7.9 Marine Benthos

Benthic USA LLC. 2019. Environmental Baseline Study Liza Phase 2 Field Development Guyana. A report for Esso Exploration and Production Guyana Ltd.

CEGA (Centre for Environmental Genomics Applications). 2019. Preliminary eDNA analysis of Guyana Samples (2016-17).

Davies, C.E., D. Moss, and M.O. Hill. 2004. EUNIS Habitat Classification Revised 2004. Accessed: July 2021. Retrieved from: http://eunis.eea.europa.eu/references/1473

Ellis, D.V., and C. Heim. 1985. Submersible Surveys of Benthos near a Turbidity Cloud. *Mar Poll Bull*, 16(5): 197–203.

EPA (Guyana Environmental Protection Agency). 2010. Guyana Fourth National Report to the Convention on Biological Diversity, 2010. Accessed: July 2021. Retrieved from: http:// www.cbd.int/doc/world/gy/gy-nr-04-en.pdf

ERM (Environmental Resources Management). 2018. Nearshore and Offshore Fisheries Study Summary Report 2017–2018. Liza Phase 1 Development Project. Prepared for Esso Exploration and Production Guyana Limited. May 2018.

ESL (Environmental Services Limited). 2018a. Final Environmental Baseline Sediment Quality Report for Exxon Guyana Project: Phase 2 Offshore Guyana. April 2018.

_____. 2018b. Final Water Quality Report for Exxon Guyana Project: Phase 1 Offshore Guyana. January 2018.

Flach, E., J. Vanaverbeke, and C. Heip. 1999. The Meiofauna: Macrofauna Ratio across the Continental Slope of the Goban Spur (North-east Atlantic). *Journal of the Marine Biological Association of the United Kingdom*, 79: 233–241. Accessed: July 2021. Retrieved from: https://pure.knaw.nl/portal/files/472420/Flach_ea_2380.pdf

Freiwald, A., J.H. Fosså, A. Grehan, T. Koslow, and J.M. Roberts. 2004. Cold-water Coral Reefs. UNEP-WCMC, Cambridge, UK. Accessed: July 2021. Retrieved from: https://www.researchgate.net/publication/230710662_Cold-water_Coral_Reefs_Out_of_Sight_-_No_Longer_out_of_Mind

Fugro. 2016. Environmental Baseline Survey Report. Liza Development, Offshore Guyana. Prepared for Esso Exploration and Production Guyana Ltd, March 2016. Fugro Job No. 2415-3066-EBS. 125 pp.

_____. 2019a. Environmental Baseline Survey and Habitat Assessment Report: Payara Development, Offshore Guyana. Fugro Document No.: 1803-1430-V8-EBS. 6 March 2019.

_____. 2019b. Desktop Study Analysis of Hard Seafloor Features. Payara and Liza Developments, Offshore Guyana. Fugro Document No.: 1901-1538-HSFDTS. 24 May 2019.

Grassle, J.F., and N. Maciolek. 1992. Deep-sea Species Richness and Local Diversity Estimates from Quantitative Bottom Samples. *American Naturalist.* 139(2):313-341.

Hendrick, V.J., Z.L. Hutchison, and K.S. Last. 2016. Sediment Burial Intolerance of Marine Macroinvertebrates. *PLOS ONE* Vol. 11(2). Accessed: July 2021. Retrieved from: https://doi.org/10.1371/journal.pone.0149114

Jones, D., J. Cruz-Motta, D. Bone, and J. Kaariainen. 2012. Effects of Oil Drilling Activity on the Deep Water Megabenthos of the Orinoco Fan, Venezuela. *Journal of the Marine Biological Association of the United Kingdom*, 92: 245–253. Accessed: July 2021. Retrieved from: https://www.researchgate.net/publication/259418552_Effects_of_oil_drilling_activity_on_the_deep_water_megabenthos_of_the_Orinoco_Fan_Venezuela

Kelly, R.P., J.A. Port, K.M. Yamahara, and L.B. Crowder. 2014. Using Environmental DNA to Census Marine Fishes in a Large Mesocosm. PLoS ONE 9(1): e86175. Accessed: July 2021. Retrieved from: https://doi.org/10.1371/journal.pone.0086175

Kilgour, M.J., and T.C. Shirley. 2008. Bathymetric and Spatial Distribution of Decapod Crustaceans on Deep-water Shipwrecks in the Gulf of Mexico. *Bulletin of Marine Science*, 82: 333–344.

Liverpool, E., M. Ram, and D. Hemraj. 2018. Identification of Deepwater Specimens (Macro-Invertebrates and Fishes) Report. Prepared on behalf of Esso Exploration and Production Guyana Limited.

Long, E.R., D.D. McDonald, S.L. Smith, and F.D. Calder. 1995. “Incidence of Adverse Biological Effects Within Range of Chemical Concentrations in Marine and Estuarine Sediments.” *Environmental Management.* 19.1 (1995): 81-97.

Lowry, J.K., and K. Dempsey. 2006. The Giant Deep-sea Scavenger Genus *Bathynomus* (Crustacea, Isopoda, Cirolanidae) in the Indo-West Pacific, in B. Richer De Forges and J. Justine. (eds.), Tropical Deep-Sea Benthos, Volume 24. *Mémoires du Muséum National d’Histoire Naturelle.* 193: 163-192. Paris ISBN: 2-85653-585-2.

MarLIN (Marine Life Information Network). 2019. MarESA Pressures and Benchmarks. The Marine Biological Association of the UK, Citadel Hill, Plymouth, Devon, U.K. Accessed: July 2021. Retrieved from: https://www.marlin.ac.uk/sensitivity/SNCB-benchmarks

Maxon Consulting, Inc., and TDI-Brooks International, Inc. 2014. Environmental Baseline Study. Guyana Stabroek Block. Prepared for Esso Exploration and Production Guyana Ltd. July 2014. Ref. 14024. 106 pp.

Maxon Consulting, Inc., TDI-Brooks International, Inc., and Benthic USA LLC. 2019. Environmental Baseline Study: Canje Block Offshore Guyana. Prepared for Esso Exploration and Production Guyana Ltd. February 2019.

Neff, J. 1997. Review: Ecotoxicology of Arsenic in the Marine Environment. *Environmental Toxicology and Chemistry*. 16(5): 917-927. Accessed: July 2021. Retrieved from: https://www.researchgate.net/publication/229608565_Ecotoxicology_of_Arsenic_in_the_Marine_Environment_-_Review

NOAA. (National Oceanic and Atmospheric Administration) 2008. Screening Quick Reference Tables (SQuiRTs). Accessed: 10 July 2019. Retrieved from: https://repository.library.noaa.gov/view/noaa/9327

_____. 2014. Deep-Sea Corals. National Marine Fisheries Service. Marine Habitat Protection Program. Accessed: July 2021. Retrieved from: http://www.habitat.noaa.gov/protection/corals/deepseacorals.html

Oliver, J., K. Hammerstrom, E. McPhee-Shaw, P. Lattery, J. Oakders, S. Kim, and S.I. Hartwell. 2011. High Species Density Patterns in Macrofaunal Invertebrate Communities in the Marine Benthos. *Marine Ecology.* 32: 278-288.

Poore, G., and M. Schotte. 2009. *Malacanthura truncata* (Hansen, 1916). In: C.B. Boyko, N.L. Bruce, K.L. Merrin, Y. Ota, G.C.B. Poore, S. Taiti, M. Schotte, and G.D.F. Wilson (eds.). 2008 (onwards). World Marine, Freshwater and Terrestrial Isopod Crustaceans database. Accessed: July 2021. Retrieved from: http://www.marinespecies.org/aphia.php?p=taxdetails&id=118479

_____. 2015. *Leptanthura guianae* Kensley, 1982. In: C.B. Boyko, N.L. Bruce, K.L. Merrin, Y. Ota, G.C.B. Poore, S. Taiti, M. Schotte, and G.D.F. Wilson (eds.). 2008 (onwards). World Marine, Freshwater and Terrestrial Isopod Crustaceans database. Accessed: 3 October 2016. Retrieved from: http://www.marinespecies.org/aphia.php?p=taxdetails&id=255553

Rowe, G.T., P. Polloni, and R.L. Haedrich. 1982. The Deep-sea Macrobenthos on the Continental Margin of the Northwest Atlantic Ocean. *Deep-Sea Research* 29A: 257–278.

Sanzone, D.M., J.M. Neff, D. Lewis, N. Vinhateiro, and J. Blake. 2016. Environmental Fates and Effects of Ocean Discharge of Drill Cuttings and Associated Drilling Fluids from Offshore Oil and Gas Operations. February 2016, International Association of Oil and Gas Producers (IOGP), Report No. 543. March 2016.

Smit, M.G.D., J.E. Tamis, R.G. Jak, C.C. Karman, G. Kjeilen-Eilertsen, H. Trannum, and J. Neff. 2006. Threshold Levels and Risk Functions for Non-toxic Sediment Stressors: Burial, Grain Size Changes and Hypoxia. Summary. TNO Report no. TNO 2006-DH-0046/A – Open.

Snyder, S., E. Pulster, D. Wetzel, and S. Murawski. 2015. "PAH Exposure in Gulf of Mexico Demersal Fishes, Post- Deepwater Horizon." *Environmental Science and Technology.* 49: 8786-8795.

Stanley, D.R., and C.A. Wilson. 1991. "Factors Affecting the Abundance of Selected Fishes near Oil and Gas Platforms in the Northern Gulf of Mexico." *Fishery Bulletin*. 89: 149–159.

Thomsen, P.F., and E. Willerslev. 2015. Environmental DNA–An Emerging Tool in Conservation for Monitoring Past and Present Biodiversity. *Biological Conservation*. 183: 4-18. Accessed: July 2021. Retrieved from: https://www.sciencedirect.com/science/article/pii/S0006320714004443

Thomsen P.F., J. Kielgast, L.L. Iversen, P.R. Møller, M. Rasmussen, and E. Willerslev. 2012. Detection of a Diverse Marine Fish Fauna Using Environmental DNA from Seawater Samples. *PLoS ONE.* 7(8): e41732. Accessed: July 2021. Retrieved from: https://doi.org/10.1371/journal.pone.0041732

Wei, C.L., G.T. Rowe, G.F. Hubbard, A.H. Scheltema, G.D.F. Wilson, I. Petrescu, J.M. Foster, M.K. Wicksten, M. Chen, R. Davenport, Y. Soliman, and Y. Wang. 2010. Bathymetric Zonation of Deep-sea Macrofauna in Relation to Export Surface Phytoplankton Production. *Marine Ecology Progress Series.* 399:1-14. Accessed: July 2021. Retrieved from: http://www.int-res.com/articles/feature/m399p001.pdf

Section 7.10 Ecological Balance and Ecosystems

Beaugrand, G. 2005. Monitoring Pelagic Ecosystems Using Plankton Indicators. *ICES Journal of Marine Science*. 62(3): 333–338.

CEGA (Centre for Environmental Genomics Applications). 2016. Liza-1 Deepwater Field: 2016 Environmental Baseline Survey Environmental Genomics Analysis. Prepared on behalf of Esso Exploration and Production Guyana Limited.

Caribbean Invasives.org. 2021. Green Mussel (*Perna virdis*). Accessed: September 2021. Retrieved from: https://caribbeaninvasives.org/index.php/2010/08/10/green-mussel-perna-virdis/

Cushing, D.H. 1997 Towards a Science of Recruitment in Fish Populations. Oldendorf/Luhe Ecology Institute.

de Macedo-Soares, L.C.P., C.A.E. Garcia, A.S. Freire, and J.H. Muelbert. 2014. “Large-Scale Ichthyoplankton and Water Mass Distribution along the South Brazil Shelf.” PLoS ONE 9, no.3: e91241. Retrieved from: https://doi.org/10.1371/journal.pone.0091241

Ditty, J.G. 1986. Ichthyoplankton in Neritic Waters of the Northern Gulf of Mexico off Louisiana: Composition, Relative Abundance, and Seasonality. *Fishery Bulletin* 84 (4): 935-946.

Espinosa-Fuentes, M. L., C. Flores-Coto, F. Zavala-García, L. Sanvicente-Añorve, and R. Funes-Rodríguez. 2013. “Seasonal Vertical Distribution of Fish Larvae in the Southern Gulf of Mexico.” *Hidrobiológica.* 23, no. 1: 42-59.

Heileman, S. 2009. XVI-52 North Brazil Shelf LME. In: K. Sherman and G. Hempel (eds.), The UNEP Large Marine Ecosystems Report: A Perspective on Changing Conditions in LMEs of the World’s Regional Seas. UNEP Regional Seas Report and Studies No. 182. United Nations Environment Programme, Nairobi, 701–710.

IMO (International Maritime Organization). 2004. International Convention for the Control and Management of Ships’ Ballast Water. BWM/CONF/36. 16 February 2004. Accessed: July 2021. Retrieved from: http://library.arcticportal.org/1913/1/International%20Convention%20for%20the%20Control%20and%20Management%20of%20Ships%27%20Ballast%20Water%20and%20Sediments.pdf

IPCC (Intergovernmental Panel on Climate Change). 2014. Climate Change 2014: Synthesis Report Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.), IPCC, Geneva, Switzerland, 151 pp.

Johannesson, K., and C. Andre. 2006. Life on the Margin: Genetic Isolation and Diversity Loss in a Peripheral Marine Ecosystem, the Baltic Sea. *Mol Ecol.* 15: 2013-2029. Retrieved from: https://doi.org/10.1111/j.1365-294X.2006.02919.x

Marineregions.org. 2019. Marine Gazetteer Place details. Accessed: 27 August 2021. Retrieved from: http://www.marineregions.org/gazetteer.php?p=details&id=8570

MCA (Maritime and Coastguard Agency). 2008. Marine Guidance Note MGN 363 (M+F). The Control and Management of Ships’ Ballast Water and Sediments. Accessed: July 2021. Retrieved from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/440722/MGN_363.pdf

Nielsen, E.E., M.M. Hansen, D.E. Ruzzante, D. Meldrup, and P. Gronkjær. 2003. Evidence of a Hybrid-zone in Atlantic Cod (*Gadus morhua*) in the Baltic and the Danish Belt Sea Revealed by Individual Admixture Analysis. *Mol Ecol.* 2003, 12: 1497-1508. Retrieved from: https://doi.org/10.1046/j.1365-294X.2003.01819.x

Nihoul, J.C.J., and C.T.A. Chen. 2008. Oceanography. Volume 1. Encyclopedia of Life Support Systems.

NOAA (National Oceanic and Atmospheric Administration). 2021. Large Marine Ecosystems: A Breakthrough Concept for Ecosystem Management. Revised January 21, 2021. Accessed: 27 August 2021. Retrieved from: https://celebrating200years.noaa.gov/breakthroughs/ecosystems/welcome.html#characteristics

NOAA Fisheries. Undated. Ecology of the Northeast U.S. Continental Shelf: Invasive Species. Accessed: 27 August 2021. Retrieved from: https://apps-nefsc.fisheries.noaa.gov/nefsc/ecosystem-ecology/invasive.html

Roemmich, D., and J. McGowan.1995 Climatic Warming and the Decline of Zooplankton in the California Current. *Science*. Vol. 267 (pg. 1324-326).

Ruiz, G., K.R. Murphy, E. Verling, G. Smith, S. Chaves, and A.H. Hines. 2005. Ballast Water Exchange: Efficacy of Treating Ships' Ballast Water to Reduce Marine Species Transfers and Invasion Success? Final Report. Submitted to: U.S. Fish & Wildlife Service, American Petroleum Institute, & Prince William Sound Regional Citizens' Advisory Council. Accessed: July 2021. Retrieved from: https://pdfs.semanticscholar.org/98c3/e8a717e1c24e8bec6c753503944f425ec4c8.pdf

Ruzzante, D.E., C.T. Taggart, and D. Cook. 1998. A Nuclear DNA Basis for Shelf- and Bank-scale Population Structure in Northwest Atlantic Cod (*Gadus morhua*): Labrador to Georges Bank. *Mol Ecol*. 1998, 7: 1663-1680. Retrieved from: https://doi.org/10.1046/j.1365-294x.1998.00497.x

Secretariat of the Convention on Biological Diversity. 2014. Ecologically or Biologically Significant Marine Areas (EBSAs): Special Places in the World's Oceans. Volume 2: Wider Caribbean and Western Mid-Atlantic Region. 86 pages. Accessed: July 2021. Retrieved from: https://www.cbd.int/marine/ebsa/booklet-02-wcar-en.pdf

Ward, R.D., M. Woodwark, and D.O.F. Skibinski. 1994. A Comparison of Genetic Diversity Levels in Marine, Freshwater and Anadromous Fishes. *J Fish Biol.* 1994, 44: Retrieved from: https://doi.org/10.1111/j.1095-8649.1994.tb01200.x

Watson, S.C.L., D.M. Paterson, A.M. Queirósa, A.P. Rees, N. Stephens, S. Widdicombe, and N.J. Beaumont. 2016. A Conceptual Framework for Assessing the Ecosystem Service of Waste Remediation: In the Marine Environment. Ecosystem Services. Volume 20, August 2016, Pages 69-81. Accessed: July 2021. Retrieved from: https://www.sciencedirect.com/science/article/pii/S2212041616301449

Xiao, N., G.J. Herndl, D.A. Hansell, R. Benner, G. Kattner, S.W. Wilhelm, D.L. Kirchman, M.G. Weinbauer, T. Luo, F. Chen, and F. Azam. 2010. Microbial Production of Recalcitrant Dissolved Organic Matter: Long-Term Carbon Storage in the Global Ocean. *Nature Reviews*. 8: 593-599.

Chapter 8 Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources

Section 8.1 Socioeconomic Conditions

Bank of Guyana. 2018. Half Year Report 2018. Accessed: July 2021. Retrieved from: https://www.bankofguyana.org.gy/bog/images/research/Reports/HalfYear2018.pdf

_____. 2019. Annual Report 2018. Accessed: July 2021. Retrieved from: https://www.bankofguyana.org.gy/bog/images/research/Reports/ANNREP2018.pdf

_____. 2021. Annual Report 2020. Accessed: July 2021. Retrieved from: https://www.bankofguyana.org.gy/bog/images/research/Reports/ANNREP2020.pdf

BSG (Bureau of Statistics Guyana). 2002. 2002 Population & Housing Census – Guyana National Report.

_____. 2012. 2012 Population & Housing Census Compendium.

_____. 2021. Guyana Labour Force Survey: 2021 First Quarter Report. May 2021. Accessed: July 2021. Retrieved from: https://statisticsguyana.gov.gy/wp-content/uploads/2019/10/GLFS_Bulletin_2021_First-_Quarter.pdf

DPI Guyana (Department of Public Information Guyana). 2018. Guyanese Will Benefit Fully from Oil and Gas Revenues – Minister Harmon. Accessed: July 2021. Retrieved from: http://dpi.gov.gy/guyanese-will-benefit-fully-from-oil-and-gas-revenues-minister-harmon/

ECLAC (Economic Commission for Latin America and the Caribbean). 2005. Guyana: Socio-economic Assessment of the Damages and Losses Caused by the January-February 2005 Flooding. Accessed: July 2021. Retrieved from: https://repositorio.cepal.org/bitstream/handle/11362/27570/LCcarL31rev1_en.pdf?sequence=1&isAllowed=y

EMC/ERM (Environmental Management Consultants/Environmental Resources Management). 2020. Participatory Fishing Study Final Report: January 2019–March 2020.

ERM (Environmental Resources Management). 2018. Nearshore and Offshore Fisheries Study Report. Technical report to Guyana EPA.

ERM/EMC (Environmental Resources Management and Environmental Management Consultants). 2018. Liza Phase 1 Enhanced Coastal Sensitivity Mapping – Ecosystem Services.

FAO (Food and Agriculture Organization of the United Nations). 2015. AQUASTAT Regional Report: Southern America, Central America and the Caribbean - Guyana. Accessed: July 2021. Retrieved from: http://www.fao.org/nr/water/aquastat/countries_regions/guy/

Garstin, A., and H.A. Oxenford. 2018. Reducing Elasmobranch Bycatch in the Atlantic Seabob (*Xiphopenaeus kroyeri*) Trawl Fishery of Guyana. *Gulf and Caribbean Research.* 29 (1): GCFI 10-GCFI 20.

GOINVEST. 2021. Accessed: July 2021. Retrieved from: https://goinvest.gov.gy/portfolio/mining/

Government of Guyana. 2021. Smart classrooms—integral to creating equity and access to education. Department of Public Information. February 2021. Accessed: July 2021. Retrieved from: https://dpi.gov.gy/smart-classrooms-integral-to-creating-equity-and-access-to-education/

Guyana Chronicle. 2015. World Bank reports…Guyana's Migration of University Graduates Highest in the World. 22 June. Accessed: July 2021. Retrieved from: http://guyana chronicle.com/2015/06/22/world-bank-reports-guyanas-migration-of-university-graduates-highest-in-the-world

_____. 2016. Pomeroon to Become Guyana's Coconut Capital. 18 July 2016. Accessed: July 2021. Retrieved from: http://guyanachronicle.com/pomeroon-to-become-guyanas-coconut-capital/

Guyana Rice Development Board. 2021. Pers. Comm. with Environmental Resources Management regarding regarding rice production. 14 June 2021.

Guyana Tourism Authority. 2018. The Guyana Tourism Authority Announces New Website Launch: Revamped Website Promotes Guyana's Rich Natural and Cultural Heritage. Accessed: August 2021. Retrieved from: https://web.archive.org/web/20190313200408/ https://www.guyanatourism.com/guyana-press-releases/

_____. 2021. Visitor Arrivals by Main Markets (1998–2021). Data table provided by Guyana Tourism Authority, by email September 2021.

IDB (Inter-American Development Bank). 2017. IDB Group Country Strategy with the Cooperative Republic of Guyana 2017-2021.

IFAD (International Fund for Agricultural Development). Undated. Hinterland Environmentally Sustainable Agricultural Development Project. Accessed: July 2021. Retrieved from: https://www.ifad.org/en/web/operations/project/id/2000001472/country/guyana

Isaac, V.J., and S.F. Ferrari. 2017. Assessment and Management of the North Brazil Shelf Large Marine Ecosystem, Environmental Development 22: 97–110.

Kaiteur News. 2021. Region Seven Financially Impacted Due to Flood Situation – Chairman. Accessed: September 2021. Retrieved from: https://www.kaieteurnewsonline.com /2021/09/22/region-seven-financially-impacted-due-to-flood-situation-chairman/

Khan, Anara. "$60.7B to transform education sector." Department of Public Information, 13 February 2021. Accessed: January 2022. Retrieved from: https://dpi.gov.gy/60-7b-to-transform-education-sector/

Kolmann, M.A., A.A. Elbassiouny, E.A. Liverpool, and N.R. Lovejoy. 2017. DNA Barcoding Reveals the Diversity of Sharks in Guyana Coastal Markets, *Neotropical Ichthyology*, 15(4): e170097, doi: 10.1590/1982-0224-20170097.

Ministry of Agriculture. 2013. Marine Fisheries Management Plan 2013-2018. Fisheries Department.

_____. 2018. Agriculture Statistics Yearbook.

_____. 2021a. Annual Production of Coconuts, Coconut Water, Roots, Vegetables, Fruits and Spices, 2014–2020. Data table provided by Ministry of Agriculture, by email 13 September 2021.

_____. 2021b. Aquaculture Fish Production, by Species (2017–2020). Data table provided by Ministry of Agriculture by email 13 September 2021.

_____. 2021c. Fishery Prices: Retail Prices for Different Catch Species in 2020. Data table provided by Ministry of Agriculture, by email 13 September 2021.

_____. 2021d. Progress of Coconut Production to Date. Data table provided by Ministry of Agriculture, by email 13 September 2021.

Ministry of Business. 2019. Guyana Records Highest Visitor Arrival Numbers. January 25, 2019. Retrieved from: https://m.facebook.com/407686749441146/posts/record-arrivals-l-guyana-continues-to-grow-as-a-destination-of-choice-for-travel/968451120031370/

Ministry of Education. 2014. Guyana Education Sector Plan 2014-2018.

Ministry of Finance. 2015. Mid-Year Report 2015. Accessed: July 2021. Retrieved from: https://finance.gov.gy/wp-content/uploads/2017/06/mid_year_2015.pdf

Minority Rights Group International. 2008. World Directory of Minorities and Indigenous Peoples - Guyana: Indigenous Peoples.

NAREI (National Agricultural Research and Extension Institute). 2017. The Coconut Industry in Guyana. Accessed: July 2021. Retrieved from: https://narei.org.gy/the-coconut-industry-in-guyana/

National Trust of Guyana. 2018. History of Georgetown. Accessed: July 2021. Retrieved from: https://ntg.gov.gy/history-of-georgetown/

News Room Guyana. 2021. Smart Classrooms Launched Targeting Hinterland Students. February 2021. Accessed: July 2021. Retrieved from: https://newsroom.gy/2021/02/02/smart-classrooms-launched-targeting-hinterland-students

Oil Now Guyana. 2018. Guyana ‘Green Goals’ to Guide How Oil Revenue is Spent. Accessed: July 2021. Retrieved from: http://oilnow.gy/featured/guyana-green-goals-guide-oil-revenue-spent/

PAC (Protected Areas Commission). 2014. Shell Beach Protected Area Management Plan, 2015-2019.

Parris, Naomi. 2021. “More room for value-added production in ‘agri’ sector.” *Guyana Chronicle*, 7 August 2021. Accessed: January 2022. Retrieved from: https://guyanachronicle.com/2021/08/07/more-room-for-value-added-production-in-agri-sector/

PSC (Private Sector Commission of Guyana). 2015. Annual Report 2015.

_____. 2017. A Review of Guyana’s Economy in 2016.

Stabroek News. 2016. Pomeroon Farmers Cashing in on Coconut Water Market. Accessed: July 2021. Retrieved from: http://www.stabroeknews.com/2016/business/05/13/pomeroon-farmers-cashing-coconut-water-market/

_____. 2018. Coconut Output Seen Quadrupling by 2025. Accessed: July 2021. Retrieved from: https://www.stabroeknews.com/2018/news/guyana/05/25/coconut-output-seen-quadrupling-by-2025/

_____. 2019. Guyana Claims “Best of Ecotourism Top Spot at World’s Leading Travel and Trade Show Berlin. Accessed: July 2021. Retrieved from: https://www.stabroek news.com/2019/business/03/08/guyana-claims-best-of-ecotourism-top-spot-at-worlds-leading-travel-trade-show-in-berlin/

_____. 2021. USAID, Guyanese-led initiative aiming to salvage agro processing sector. Accessed: November 2021. Retrieved from: https://www.stabroeknews.com/2021/07/02/business/usaid-guyanese-led-initiative-aiming-to-salvage-agro-processing-sector/

UNICEF (United Nations Children’s Fund). 2017. Study on Indigenous Women & Children in Guyana. Accessed: July 2021. Retrieved from: https://www.unicef.org/lac/media/4691/file/PDF%20Study%20on%20indigenous%20women%20and%20children%20in%20Guyana.pdf

World Bank. 2000. Migration and Remittances Factbook.

_____. 2016. International Development Association, International Finance Corporation, and Multilateral Investment Guarantee Agency Country Engagement Note for the Cooperative Republic of Guyana for the Period FY16-18. 23 March 2016. Report No. 94017-GY. Accessed: July 2021. Retrieved from: http://documents.worldbank.org/curated/en/945941467999118138/pdf/94017-REVISED-Box394888B-OUO-9-IDA-R2016-0055-2.pdf

_____. 2020. Doing Business 2020: Comparing Business Regulation in 190 Economies. Accessed: July 2021. Retrieved from: https://documents1.worldbank.org/curated/en/688761571934946384/pdf/Doing-Business-2020-Comparing-Business-Regulation-in-190-Economies.pdf

_____. 2021. World Bank Open Data: Cooperative Republic of Guyana. Accessed: July 2021. Retrieved from: https://data.worldbank.org/country/guyana?view=chart.

World Travel & Tourism Council. 2021. Guyana 2021 Annual Research: Key Highlights. Accessed: November 2021. Retrieved from: https://wttc.org/Research/Economic-Impact/moduleId/704/itemId/124/controller/DownloadRequest/action/QuickDownload

Section 8.2 Employment and Livelihoods

APA and FPP (Amerindian Peoples Association and Forest Peoples Programme). 2016. Our Land, Our Life: A Participatory Assessment of the Land Tenure Situation of Indigenous Peoples in Guyana Report for Region 1 and Region 2. Accessed: July 2021. Retrieved from: https://rainforestfoundation.org/wp-content/uploads/APA_LTA_R1_R2.pdf

Bank of Guyana. 2019. Annual Report 2019. Accessed: July 2021. Retrieved from: https://bankofguyana.org.gy/bog/images/research/Reports/ANNREP2019.pdf

BSG (Bureau of Statistics Guyana). 2016. 2012 Census - Compendium 3: Economic Activity.

_____. 2018a. Guyana Labour Force Survey: 2017 Third Quarter Report. Accessed: July 2021. Retrieved from: https://statisticsguyana.gov.gy/wp-content/uploads/2019/10/GLFS_2017_Quarter3_Final-PDF-1.8MB.pdf

_____. 2018b. Guyana Labour Force Survey: 2017 Fourth Quarter Report. Accessed: July 2021. Retrieved from: https://statisticsguyana.gov.gy/wp-content/uploads/2019/10/GLFS_2017_Quarter4_Final-PDF-1.4MB.pdf

_____. 2019. Guyana Labour Force Survey: 2018 Report. June 2019. Accessed: July 2021. Retrieved from: https://statisticsguyana.gov.gy/wp-content/uploads/2019/10/GLFS_Bulletin_2018.pdf

_____. 2020a. Guyana Labour Force Survey: 2019 Report. June 2020. Accessed: July 2021. Retrieved from: https://statisticsguyana.gov.gy/wp-content/uploads/2020/07/GLFS_Bulletin_2019.pdf

_____. 2020b. Guyana Labour Force Survey: 2020 First Quarter Report. October 2020. Accessed: July 2021. Retrieved from: https://statisticsguyana.gov.gy/wp-content/uploads/2020/10/GLFS_Bulletin_2020_First_Quarter.pdf

_____. 2021. Guyana Labour Force Survey: 2021 First Quarter Report. May 2021. Accessed: July 2021. Retrieved from: https://statisticsguyana.gov.gy/wp-content/uploads/2019/10/GLFS_Bulletin_2021_First-_Quarter.pdf

Chabrol, D. 2021. “Suriname’s plan to licence Guyanese fishing vessels triggers concerns.” *Demerara Waves*. 20 August 2021. Accessed: November 2021. Retrieved from: https://demerarawaves.com/2021/08/20/surinames-plan-to-licence-guyanese-fishing-vessels-triggers-concerns/

ECLAC (Economic Commission for Latin American and the Caribbean). 2011. An Assessment of the Economic Impact of Climate Change on the Agriculture Sector in Guyana. Accessed: July 2021. Retrieved from: http://repositorio.cepal.org/bitstream/handle/11362/38586/LCCARL323_en.pdf;jsessionid=6A80E60D052D8EB7A38956A1033254D8?sequence=1

EMC (Environmental Management Consultants Inc.). 2021. Participatory Fish Study: Quarterly Report April–June 2021.

ERM (Environmental Resources Management). 2018. Nearshore and Offshore Fisheries Study Report. Technical report to Guyana EPA.

ERM/EMC (Environmental Resources Management and Environmental Management Consultants). 2018. Liza Phase 1 Enhanced Coastal Sensitivity Mapping – Ecosystem Services.

FAO (Food and Agriculture Organization of the United Nations). 2015. AQUASTAT Regional Report: Southern America, Central America and the Caribbean - Guyana. Accessed: July 2021. Retrieved from: http://www.fao.org/nr/water/aquastat/countries_regions/guy/

_____. 2021. MCS Training for Brazil, Guyana, Suriname and Trinidad and Tobago. Accessed: July 2021. Retrieved from: http://www.fao.org/iuu-fishing/news-events/detail/en/c/1391673/

GoG (Government of Guyana). 2018. National Policy on Occupational Safety and Health 2018. Prepared by the Guyana Ministry of Social Protection and the National Advisory Council on Occupational Safety and Health (NACOSH) in collaboration with the International Labour Organization. Accessed: July 2021. Retrieved from: https://www.ilo.org/wcmsp5/groups/public/---americas/---ro-lima/---sro-port_of_spain/documents/publication/wcms_694979.pdf

Guyana Chronicle. 2021. Significant amount of crops destroyed as a result of flooding. 1 July 2021. Accessed: July 2021. Retrieved from: https://guyanachronicle.com/2021/07/01/significant-amount-of-crops-destroyed-as-a-result-of-flooding/

IDB (Inter-American Development Bank). 2007. Guyana: Technical Note on Indigenous Peoples. September. Accessed: July 2021. Retrieved from: https://publications.iadb.org/bitstream/handle/11319/5974/Guyana%3a%20Technical%20Note%20on%20Indigenous%20Peoples%20.pdf?sequence=1&isAllowed=y

IMF (International Monetary Fund). 2021. Country data: Guyana. Accessed: July 2021. Retrieved from: https://www.imf.org/en/Countries/GUY

Ministry of Agriculture. 2016. FAO Country Rep Lauds Guyana's Efforts to Stop Illegal Fishing. Accessed: July 2021. Retrieved from: http://agriculture.gov.gy/2016/04/15/fao-country-rep-lauds-guyanas-efforts-to-stop-illegal-fishing/

Ministry of Finance. 2015. Mid-Year Report 2015. Sessional Paper No. 2 OF 2015. Accessed: July 2021. Retrieved from: https://finance.gov.gy/wp-content/uploads/2017/06/mid_year_2015.pdf

Ministry of Natural Resources. 2021. Local Content Policy for the Development of Guyana's Petroleum Economy. Revised draft February 2021).

Minority Rights Group International. 2018. World Directory of Minorities and Indigenous Peoples - Guyana: Indigenous Peoples. Updated January 2018. Accessed: July 2021. Retrieved from: https://minorityrights.org/country/guyana/

PAC (Protected Areas Commission). 2014. Shell Beach Protected Area Management Plan, 2015-2019.Community Health and Wellbeing

Stabroek News. 2020. Piracy attack that killed 12 Guyanese linked to turf war – inquiry. 21 February 2020. Accessed: July 2021. Retrieved from: https://www.stabroeknews.com/2020/02/21/news/guyana/piracy-attack-that-killed-12-guyanese-linked-to-turf-war-inquiry/

UNICEF (United Nations Children's Fund). 2017. Study on Indigenous Women & Children in Guyana. Accessed: July 2021. Retrieved from: https://www.unicef.org/lac/media/4691/file/PDF%20Study%20on%20indigenous%20women%20and%20children%20in%20Guyana.pdf

WFP (World Food Programme). 2020. Caribbean COVID-19 Food Security & Livelihoods Impact Survey: Guyana Summary Report. United Nations World Food Programme and CARICOM. May 2020. Accessed: July 2021. Retrieved from: https://docs.wfp.org/api/documents/WFP-0000115925/download/

Section 8.3 Community Health and Wellbeing

BSG (Bureau of Statistics Guyana), Ministry of Public Health, and UNICEF. 2015. Guyana Multiple Indicator Cluster Survey 2014, Final Report. Georgetown, Guyana: Bureau of Statistics, Ministry of Public Health and UNICEF.

CDEMA (Caribbean Disaster Emrgency Management Agency. "Guyana and Suriname impacted by adverse flooding." *Flooding in Guyana Suriname Situation Report No. 2.* As of 3:00 PM on 23 June 2021. Accessed: July 2021. Retrieved from: https://www.cdema.org/images/2021/06/CDEMA_Situation_Report_2_Flooding_in_Guyana__Suriname_22June_2021.pdf

Centers for Disease Control and Prevention. 2019. Indoor Residual Spraying. Accessed: July 2021. Retrieved from: https://www.cdc.gov/malaria/malaria_worldwide/reduction/irs.html

Ding, Q., X. Chen, R. Hilborn, and Y. Chen. 2107. Vulnerability to Impacts of Climate Change on Marine Fisheries and Food Security, *Marine Policy* 83:55–61.

DPI Guyana (Department of Public Information Guyana). 2021. Min. Anthony pleased with budget allocation for health. Accessed: July 2021. Retrieved from: https://dpi.gov.gy/min-anthony-pleased-with-budget-allocation-for-health/

ECLAC (Economic Commission for Latin America and the Caribbean). 2005. Guyana: Socio-economic Assessment of the Damages and Losses Caused by the January-February 2005 Flooding. Accessed: July 2021. Retrieved from: https://repositorio.cepal.org/bitstream/handle/11362/27570/LCcarL31rev1_en.pdf?sequence=1&isAllowed=y

ERM/EMC (Environmental Resources Management and Environmental Management Consultants). 2018. Liza Phase 1 Enhanced Coastal Sensitivity Mapping – Ecosystem Services.

Green State Development Strategy. 2019. Green State Development Strategy Vision 2040. Accessed: July 2021. Retrieved from: https://doe.gov.gy/published/document/5cd1d69fe5569929a69b35b0

Guyana Chronicle. 2018. Improved Housing, Water for Hinterland Communities. Accessed: July 2021. Retrieved from: http://guyanachronicle.com/2018/01/08/improved-housing-water-for-hinterland-communities

Guyana Times. 2019. $1.3 B in Damages Caused by Floods Annually in Georgetown. Accessed: July 2021. Retrieved from: https://guyanatimesgy.com/1-3b-in-damages-caused-by-floods-annually-in-georgetown/

_____. 2021. Region 9 battling dengue, malaria, more floods—Chairman. Accessed July 2021. Retrieved from: https://guyanatimesgy.com/region-9-battling-dengue-malaria-more-floods-chairman/

IFC (International Finance Corporation). 2009. Introduction to Health Impact Assessment. Accessed: July 2021. Retrieved from: https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/publications/publications_handbook_healthimpactassessment__wci__1319578475704

IHME (Institute for Health Metrics and Evaluation). 2017. Guyana. Accessed: July 2021. Retrieved from: http://www.healthdata.org/guyana

Inter-Agency Standing Committee and the European Commission. 2020. INFORM Report 2020: Shared evidence for managing crisis and disaster. Publications Office of the European Union. Accessed: July 2021. Retrieved from: https://reliefweb.int/sites/reliefweb.int/files/resources/01%20Inform%202020%20ONLINE.pdf

Knoema. 2020. Guyana—Incidence of tuberculosis. Accessed: July 2021. Retrieved from https://knoema.com/atlas/Guyana/Incidence-of-tuberculosis

Malaria Atlas Project. 2021. Guyana. Accessed: July 2021. Retrieved from: https://malariaatlas.org/trends/country/GUY

Ministry of Agriculture. 2011. Food and Nutrition Security Strategy for Guyana 2011–2020. Accessed: July 2021. Retrieved from: http://extwprlegs1.fao.org/docs/pdf/guy166205.pdf

Ministry of Finance. 2018. Transforming the Economy, Empowering People, Building Sustainable Communities for the Good Life: Budget 2019. Accessed: July 2021. Retrieved from: https://finance.gov.gy/wp-content/uploads/2021/01/Budget-2019-Speech.pdf

Ministry of Health. 2013a. Guyana Strategic Plan for the Integrated Prevention and Control of Chronic NCDs and their Risk Factors 2013-2020. Accessed: July 2021. Retrieved from: https://www.mindbank.info/item/5339

_____. 2013b. Health Vision 2020: A National Health Strategy for Guyana, 2013-2020. Accessed: July 2021. Retrieved from: https://www.paho.org/guy/index.php?option=com_docman&view=download&category_slug=health-systems-and-services&alias=123-guy-healthvision-2013-2020&Itemid=291

_____. 2016. Regional Health Facilities. Accessed: July 2019. Retrieved from: https://www.health.gov.gy/index.php/world-news/central-board-of-health-8

_____. 2020. Health Facilities. Accessed: July 2021. Retrieved from: https://health.gov.gy/index.php/11-health-facilities

_____. 2021. Guyana COVID-19 Dashboard. Accessed: September 2021. Retrieved from: https://www.health.gov.gy/index.php/component/k2/item/541-guyana-covid-19-dashboard

Ministry of Local Government and Regional Development. 2016 Hinterland Sustainable Housing Programme. Accessed: July 2021. Retrieved from: https://mlgrd.gov.gy/project/hinterland-sustainable-housing-programme/

Newsroom Guyana. 2021. *COVID-19: 5 more dead, 33 in ICU; more beds being added to COVID hospital*. [online] Accessed: 24 September 2021. Retrieved from: https://newsroom.gy/2021/08/31/covid-19-5-more-dead-33-in-icu-more-beds-being-added-to-covid-hospital/

OECD (Organisation for Economic Co-operation and Development). 2013a. Crude Birth Rate. Accessed: July 2021. Retrieved from: https://stats.oecd.org/glossary/detail.asp?ID=490

_____. 2013b. Crude Death Rate. Accessed: July 2021. Retrieved from: https://stats.oecd.org/glossary/detail.asp?ID=491

OSAC (Overseas Security Advisory Council). 2020. Guyana 2020 Crime & Safety Report. Overseas Security Advisory Council, Bureau of Diplomatic Security, US Department of State. 27 March 2020. Accessed: July 2021. Retrieved from: https://www.osac.gov/Country/Guyana/Content/Detail/Report/736ce36a-b933-4293-838a-184d53f8a6aa

PAHO (Pan-American Health Organization). 2005. Disasters: Preparedness and Mitigation in the Americas: Floods in Guyana – January/February 2005. Page 4. Accessed: July 2021. Retrieved from: https://iris.paho.org/bitstream/handle/10665.2/51348/NL098e.pdf?sequence=1&isAllowed=y

Persaud, S. 2013. Presentation on Bi-national Commission on Health Guyana Suriname, National Health Care System of Guyana. July 2013.

Rios, Ana Maria. Number of malaria cases in Guyana from 2010 to 2019. 7 May 2021. Accessed: July 2021. Retrieved from: https://www.statista.com/statistics/998418/number-reported-malaria-cases-guyana/

Stabroek News. 2020. $51.7B for health budget—$11B for GPH, AIDS programme to be revived. 12 September 2020. Accessed: July 2021. Retrieved from: https://www.stabroeknews.com/2020/09/12/news/guyana/51-7b-for-health-budget/

UNAIDS. 2021. AIDSinfo: Guyana. Accessed: July 2021. Retrieved from: http://aidsinfo.unaids.org/

UNICEF (United Nations Children's Fund). 2014. Guyana Multiple Indicator Cluster Survey 5.

USAID (United States Agency for International Development). 2014. Communication Strategy for Malaria Control, Co-operative Republic of Guyana 2014-2016. Accessed: July 2021. Retrieved from: http://linksglobal.org/AMI/extras/Guyana_Communication_Strategy_LM.pdf

UNDP (United Nations Development Program). Undated_a. Millenium Development Goals Guyana: Eight Goals for 2015. Accessed: July 2021. Retrieved from: https://www.undp.org/content/dam/undp/library/MDG/english/MDG%20Country%20Reports/Guyana/MDG%20Guyana%20Progress%20Report%202011.pdf

_____. Undated_b. Sustainable Development Goals Guyana. Accessed: July 2021. Retrieved from: http://www.gy.undp.org/content/guyana/en/home/sustainable-development-goals.html

Village Voice News. 2021. Qatar field hospital expected today. Accessed: November 2021. Retrieved from: https://villagevoicenews.com/2021/01/19/qatar-field-hospital-expected-today/

WHO (World Health Organization). 2006. Constitution of the World Health Organization. Basic Documents, Forty-fifth edition, Supplement, October 2006. Accessed: July 2021. Retrieved from: http://www.who.int/governance/eb/who_constitution_en.pdf

_____. 2016. Global Health Estimates 2015: Deaths by Cause, Age, Sex, by Country and by Region, 2000–2015. Geneva: World Health Organization. Accessed: 27 March 2018. Retrieved from: http://www.who.int/entity/healthinfo/global_burden_disease/GHE2015_Deaths_Global_2000_2015.xls?ua=1

_____. 2017. Suicide Rates (per 100,000 population). Accessed: July 2021. Retrieved from: https://www.who.int/gho/mental_health/suicide_rates/en/

_____. 2018. Non-Communicable Diseases Country Profile: Guyana. Accessed: July 2021. Retrieved from: https://www.who.int/nmh/countries/guy_en.pdf?ua=1

_____. 2019. Tuberculosis profile (Guyana Country Profile). Accessed: July 2021. Retrieved from: https://worldhealthorg.shinyapps.io/tb_profiles/?_inputs_&entity_type=%22country%22&lan=%22EN%22&iso2=%22GY%22

_____. 2021.The Global Health Observatory: Indicators. Accessed: July 2021. Retrieved from: https://www.who.int/data/gho/data/indicators

World Bank. 2016. International Development Association, International Finance Corporation, and Multilateral Investment Guarantee Agency Country Engagement Note for the Cooperative Republic of Guyana for the Period FY16-18. 23 March 2016. Report No. 94017-GY. Accessed: July 2021. Retrieved from: http://documents.worldbank.org/curated/en/945941467999118138/pdf/94017-REVISED-Box394888B-OUO-9-IDA-R2016-0055-2.pdf

_____. 2020. International Development Association Project Appraisal Document on a Proposed Credit in the Amount of SDR 5.4 Million (US$7.5 Million Equivalent) to the Co-Operative Republic of Guyana for Guyana Covid-19 Emergency Response Project under the Covid-19 Strategic Preparedness and Response Program (SPRP) Using the Multiphase Programmatic Approach (MPA) With a Financing Envelope of up to US$6 Billion. Accessed: November 2021. Retrieved from: https://documents1.worldbank.org/curated/en/568831609126863176/pdf/Guyana-COVID-19-Emergency-Response-Project.pdf

_____. 2021. Cause of death, by non-communicable diseases (% of total) – Guyana. Accessed: July 2021. Retrieved from: https://data.worldbank.org/indicator/SH.DTH.NCOM.ZS?locations=GY

Section 8.4 Marine Use and Transportation

Chin, Nickolas. 2021. Pers. Comm. Interview with Transport and Harbours Department. 19 July 2021.

Gonsalves, E. 2018. Pers. Comm. with Environmental Resources Management, April 2018.

_____. 2021a. Pers. Comm. with Environmental Resources Management regarding interview with speedboat monitor at the Stabroek Market wharf. 21 June 2021.

_____. 2021b. Pers. Comm. with Environmental Resources Management regarding interview with Pilot Lindsay Baird. 22 June 2021.

_____. 2021c. Pers. Comm with Environmental Resources Management regarding interview with Pilot Lindsay Baird. 13 July 2021.

NGIA (National Geospatial-Intelligence Agency). 2017. Sailing Directions (Enroute), East Coast of South America. Publication 124, Fifteenth Edition. Updated 10 April 2021. Accessed: July 2021. Retrieved from: https://msi.nga.mil/api/publications/download?key=16694491/SFH00000/Pub124bk.pdf

Section 8.5 Social Infrastructure and Services

Ahamad, Rehana. 2021. “Extension of CJIA runway complete.” *Guyana Chronicle*. 21 March 2021. Accessed: July 2021. Retrieved from: https://guyanachronicle.com/2021/03/21/extension-of-cjia-runway-complete/.

BSG (Bureau of Statistics Guyana). 2012. 2012 Population & Housing Census Compendium.

Bureau of Statistics, Ministry of Health and UNICEF. 2015. Guyana Multiple Indicator Cluster Survey 2014, Key Findings. Georgetown, Guyana: Bureau of Statistics, Ministry of Health and UNICEF. Accessed: July 2021. Retrieved from: https://mics-surveys-prod.s3.amazonaws.com/MICS5/Latin%20America%20and%20Caribbean/Guyana/2014/Key%20findings/Guyana%202014%20MICS%20KFR_English.pdf

CARITRANS. 2018. Traffic Impact Assessment. Esso Exploration and Guyana Production Limited Liza Phase 2 Development Project.

Climatescope. 2017. Guyana. Accessed: July 2021. Retrieved from: http://2017.global-climatescope.org/en/country/guyana/#/enabling-framework

Datareportal.com. 2020. Digital 2020: Guyana. 18 February 2020. Accessed: November 2021. Retrieved from: https://datareportal.com/reports/digital-2020-guyana

DPI (Department of Public Information). 2019a. Norway Approves $16 Billion for Development of Solar Farms. Accessed: July 2021. Retrieved from: https://dpi.gov.gy/norway-approves-16billion-for-development-of-solar-farms/

_____. 2019b. US$8M Solar Power Installations for Hinterland. Accessed: July 2021. Retrieved from: https://dpi.gov.gy/us8m-solar-power-installations-for-hinterland/

ERM/EMC (Environmental Resources Management and Environmental Management Consultants). 2018. Liza Phase 1 Enhanced Coastal Sensitivity Mapping – Ecosystem Services.

ERM, EMC, and GSEC (Environmental Resources Management, Environmental Management Consultants, and Ground Structures Engineering Consultants). 2018. Environmental Impact Assessment for Liza Phase 2 Development Project. Prepared for Esso Exploration and Production Guyana Limited. February 2017. Volumes I–III.

Explore Guyana. Undated. Guyana Marriott Hotel. Accessed: July 2021. Retrieved from: http://exploreguyana.org/portfolio-item/guyana-marriott-hotel/

FAO (Food and Agriculture Organization of the United Nations). 2015. AQUASTAT Regional Report: Southern America, Central America and the Caribbean - Guyana. Accessed: July 2021. Retrieved from: http://www.fao.org/nr/water/aquastat/countries_regions/guy/

_____. 2021. AQUASTAT–Guyana. Accessed August 2021. Retrieved from: http://www.fao.org/aquastat/statistics/query/results.html

e-Governance Academy. 2018. Digital Governance Roadmap for Guyana. Version 2.0 of 25 October 2018. Accessed: October 2012. Retrieved from: https://ndma.gov.gy/wp-content/uploads/2020/01/DigitalGovernanceRoadmap_20181025.pdf

GCAA (Guyana Civil Aviation Authority). 2018. Guyana Civil Aviation Authority Website. Accessed: May 2018. Retrieved from: https://gcaa-gy.org/

GEA (Guyana Energy Agency). Undated. Solar Energy. Accessed: July 2021. Retrieved from: https://gea.gov.gy/solar/

_____. 2016. Strategic Plan 2016–2020. Accessed: July 2021. Retrieved from: https://www.gea.gov.gy/downloads/Strategic-Plan-2016-2020.pdf

GoG (Government of Guyana). 2006. Guyana Transport Sector Study.

GPL (Guyana Power & Light Inc.). 2011. Development and Expansion Programme 2012–2016. Accessed: July 2021. Retrieved from: https://gplinc.com/pl/plc/media/DE-Programme-2012-2016.pdf

GTA (Guyana Tourism Authority). 2018. Guyana Tourism Statistical Digest, 2017 Edition.

Guyana Chronicle. 2018. Improved Housing, Water for Hinterland Communities. Accessed: July 2021. Retrieved from: http://guyanachronicle.com/2018/01/08/improved-housing-water-for-hinterland-communities

_____. 2019. Gov't, GTT Sign Pact to Fast Track Liberalisation of Telecoms Sector. Accessed: July 2021. Retrieved from: http://guyanachronicle.com/2019/03/07/govt-gtt-sign-pact-to-fast-track-liberalisation-of-telecoms-sector

_____. 2021. Installation of $200M landing system completed at CJIA. 27 June 2021. Accessed: July 2021. Retrieved from: https://guyanachronicle.com/2021/06/27/installation-of-200m-landing-system-completed-at-cjia/

Guyana Tourism Authority. 2021a. Hotel Occupancy (Available Rooms). Provided to ERM by email, September 2021.

_____. 2021b. Visitor Arrivals by Months and Main Markets. Provided by email to ERM, September 2021.

GWI (Guyana Water Inc.). Undated_a. Homepage. Accessed: September 2021. Retrieved from: https://www.gwiguyana.gy/.

_____. Undated_b. Sanitation. Accessed: September 2021. Retrieved from: Sanitation | Guyana Water Inc. (gwiguyana.gy)

_____. 2020. Strategic Plan, 2021-2025. Accessed: September 2021. Retrieved from: https://www.gwiguyana.gy/system/files/docs/2021-06-08_14/Guyana%20Water%20Incorporated%20Strategic%20Plan%20%282021-2025%29.pdf

IDB (Inter-American Development Bank). 2015. Tourism and Ecotourism Development in Guyana. Issues and Challenges and the Critical Path Forward.

_____. 2016a. Review of the IDB Support to Housing Programs in the Caribbean: Support Paper. Office of Evaluation and Oversight. Accessed: July 2021. Retrieved from: https://publications.iadb.org/bitstream/handle/11319/7631/Approach-Paper-Review-of-the-IDB-Support-to-Housing-Programs-in-the-Caribbean.pdf?sequence=1

_____. 2016b. The State of Social Housing in Six Caribbean Countries.

_____. 2016c. Technical Cooperation (TC) Guyana. TC Document GY-T1134. Accessed: July 2021. Retrieved from: http://idbdocs. iadb.org/wsdocs/getdocument.aspx?docnum= 40833781

_____. 2019. Country Infrastructure Briefs: Caribbean Region. Accessed: July 2021. Retrieved from: https://publications.iadb.org/en/country-infrastructure-briefs-caribbean-region

Kaieteur News. 2021. EPA exempts New Demerara River Bridge from Environmental Impact studies. 21 August 2021. Accessed: September 2021. Retrieved from: https://www.kaieteurnewsonline.com/2021/08/21/epa-exempts-new-demerara-river-bridge-from-environmental-impact-studies/

Ministry of Education. Undated. List of Schools. Accessed: July 2021. Retrieved from: https://education.gov.gy/web2/index.php/other-resources/other-files/list-of-schools?filter%5Bsearch%5D=&limit=100

Ministry of Finance. 2015. Mid-Year Report 2015. Accessed: July 2021. Retrieved from: https://finance.gov.gy/wp-content/uploads/2017/06/mid_year_2015.pdf

MoPW (Ministry of Public Works). 2018. CJIA Expansion Project. Accessed: July 2021. Retrieved from: https://mopw.gov.gy/projects/cjia-expansion-project-0

_____. 2021. Project Summary: Replacement of the Existing Demerara Harbour Bridge. August 2021. Accessed: September 2021. Retrieved from: https://www.epaguyana.org/epa/project-summary2/summary/5-project-summary/759-replacement-demerara-harbour-bridge-project-summary

OilNOW. 2021. EIA submitted for Guyana's first large-scale wind farm. 1 June 2021. Accessed: July 2021. Retrieved from: https://oilnow.gy/featured/eia-submitted-for-guyanas-first-large-scale-wind-farm/

OSAC (Overseas Security Advisory Council). 2020. Guyana 2020 Crime & Safety Report. United States Department of State, Bureau of Diplomatic Security. Accessed: July 2021. Retrieved from: https://www.osac.gov/Content/Report/736ce36a-b933-4293-838a-184d53f8a6aa

Papannah, David. 2020. "US$90M Hilton project among four chain-branded hotels for development." *Stabroek News*. 24 November 2020. Accessed: August 2021. Retrieved from: https://www.stabroeknews.com/2020/11/24/news/guyana/us90m-hilton-project-among-four-chain-branded-hotels-for-development/

Ragobeer, Vishani. 2020. "Tourism breathes again." *Guyana Chronicle*. 1 December 2020. Accessed: July 2021. Retrieved from: https://guyanachronicle.com/2020/12/01/tourism-breathes-again/

_____. 2021. "$488M saved with solar panels on gov't buildings." *Guyana Chronicle*. 4 August 2021. Accessed: July 2021. Retrieved from: https://guyanachronicle.com/2021/04/04/488m-saved-with-solar-panels-on-govt-buildings/

Ramroop, Dhanash. 2019. Hope Wind Farm to Save GPL US$6.5M in Fuel Imports, Supply 7% Grid Demand. Accessed: July 2021. Retrieved from: https://www.stabroeknews.com/2019/news/guyana/06/23/hope-wind-farm-to-save-gpl-us6-5m-in-fuel-imports-supply-7-grid-demand/

Stabroek News. 2017. Guyana Recognised as Most Improved Member State at Aviation Forum – GCAA. Accessed: July 2021. Retrieved rom: https://www.stabroeknews.com/2017/12/21/news/guyana/guyana-recognised-as-most-improved-member-state-at-aviation-forum-gcaa/

TripAdvisor.com. 2021. Guyana Marriott Hotel Georgetown pricing information. Accessed: July 2021. Retrieved from: https://www.tripadvisor.com/Hotel_Review-g294078-d7143305-Reviews-Guyana_Marriott_Hotel_Georgetown-Georgetown_Demerara_Mahaica.html

U.S. Department of Energy. 2020. Energy Transitions Initiative: Guyana Energy Snapshot. DOE/GO-102020-5402. August 2020. Accessed: July 2021. Retrieved from: https://www.nrel.gov/docs/fy20osti/76645.pdf

University of Guyana. 2021. *University of Guyana Annual Report 2019–2020*. 9 January 2021. Accessed: January 2022. Retrieved from: https://issuu.com/uog.edu.gy/docs/ug_annual_report__2019-2020_

World Bank. 2011. The Air Connectivity Index Measuring Integration in the Global Air Transport Network.

World Economic Forum. 2015. The Travel & Tourism Competitiveness Report 2015: Growth through Shocks. Accessed July 2021. Retrieved from: http://www3.weforum.org/docs/TT15/WEF_Global_Travel&Tourism_Report_2015.pdf

Section 8.6 Waste Management Infrastructure and Capacity

Damon, Neola. 2021. Cell Two of Haags Bosch Landfill officially opens. Department of Public Information, 20 March 2021. Accessed: August 2021. Retrieved from: Cell Two of Haags Bosch Landfill officially opens – Department of Public Information (dpi.gov.gy)

Garnett, Tamica. 2021. “Temporary dumpsites for Regions 2, 3 and 5.” *Guyana Chronicle*, 16 February, 2021. Accessed: August 2021. Retrieved from: https://guyanachronicle.com/2021/02/16/temporary-dumpsites-for-regions-2-3-and-5/

Gilkes, G.F. 2017. National Integrated Solid Waste Management Strategy: “Putting Waste in its Place.” Presentation at Waste Management Workshop. Georgetown, Guyana, July 2017.

OGP (International Association of Oil & Gas Producers). 2009. Guidelines for Waste Management With Special Focus on Areas with Limited Infrastructure. Report No. 413, rev1.1. Accessed: July 2021. Retrieved from: http://inswa.or.id/wp-content/uploads/2012/07/Guidelines-for-waste-management-with-special-focus-on-areas-with-limited-infrastructure.pdf

Section 8.7 Cultural Heritage

BOEM (U.S. Department of the Interior, Bureau of Ocean Energy Management). 2017. Guidelines for Providing Archaeological and Historic Property Information Pursuant to 30 CFR Part 585. March 2017. Accessed: July 2021. Retrieved from: https://www.boem.gov/Guidelines_for_Providing_Archaeological_and_Historic_Property_Information_Pursuant_to_30CFR585/

Fugro. 2019. Volume 9: AUV Geophysical Results and Interpretation Report, Payara Development, Offshore Guyana. Fugro Document No.: 1803-1430-V9-GEOP. Prepared for Esso Exploration and Production Guyana Limited

Guardian Geomatics. 2020. Yellowtail Project Final Geophysical Report: Geophysical Development Survey – SE Stabroek Block Offshore. Prepared on behalf of Ocean Infinity. 09 November 2020.

Historic England. 2013. Marine Geophysics Data Acquisition, Processing and Interpretation: Guidance Notes. Accessed: July 2021. Retrieved from: https://content.historicengland.org.uk/images-books/publications/marine-geophysics-data-acquisition-processing-interpretation/MGDAPAI-guidance-notes.pdf/

Section 8.8 Land Use

DCRA (Deeds and Commercial Registries Authority. Undated. The Deeds and Commercial Registries Authority: Who we are. Accessed: July 2021. Retrieved from: https://dcra.gov.gy/

FAO (Food and Agriculture Organization of the United Nations). 2015. AQUASTAT Regional Report: Southern America, Central America and the Caribbean - Guyana. Accessed: July 2021. Retrieved from: http://www.fao.org/nr/water/aquastat/countries_regions/guy/

FAO and GLSC (Food and Agriculture Organization of the United Nations and Guyana Lands and Surveys Commission). 2017. Mainstreaming Sustainable Land Development and Management in the Co-operative Republic of Guyana. Accessed: July 2021. Retrieved from: http://www.guyanareddfund.org/images/stories/ProjectDocuments/SLDM-Project-Document-v3-for-Submission-to-GRIF-Steering-Committee-29-11-17.pdf

GCCI (Georgetown Chamber of Commerce & Industry. 2019. National land policy, database being developed—GL&SC. Accessed: July 2021. Retrieved from: https://gcci.gy/national-land-policy-database-being-developed-glsc/

GLSC (Guyana Lands and Surveys Commission). 2013. Guyana National Land Use Plan. Accessed: July 2021. Retrieved from: http://extwprlegs1.fao.org/docs/pdf/guy178057.pdf

IDB (Inter-American Development Bank). 2010. Guyana Property Rights Study: Discussion Paper IDB-DP-141.

Land Registry. Undated. The Land Registry: Who We Are. Accessed: July 2021. Retrieved from: https://landregistry.gov.gy/

World Bank. 2021. Agricultural land (% of land area)—Guyana. Accessed: July 2021. Retrieved from: https://data.worldbank.org/indicator/AG.LND.AGRI.ZS?locations=GY

Section 8.9 Ecosystem Services

ERM/EMC (Environmental Resources Management and Environmental Management Consultants). 2018. Liza Phase 1 Enhanced Coastal Sensitivity Mapping – Ecosystem Services.

IFC (International Finance Corporation). 2012. Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources. 1 January 2012. Accessed: July 2021. Retrieved from: https://www.ifc.org/wps/wcm/connect/3baf2a6a-2bc5-4174-96c5-eec8085c455f/PS6_English_2012.pdf?MOD=AJPERES&CVID=jxNbLC0

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: A Framework for Assessment.

Sutherland, Laurel. 2021. “Region One under pressure from surge of Venezuelans.” *Stabroek News*. 24 January 2021. Accessed: October 2021. Retrieved from: https://www.stabroeknews.com/2021/01/24/news/guyana/region-one-under-pressure-from-surge-of-venezuelans/

WWF (World Wildlife Fund). 2021. Eastern South America: Coastal French Guiana, Suriname, Guyana, and Southeastern Venezuela. Accessed: July 2021. Retrieved from: http://www.worldwildlife.org/ecoregions/nt1411

Section 8.10 Indigenous Peoples

BSG (Bureau of Statistics Guyana). 2012. 2012 Population & Housing Census Compendium.

EMC (Environmental Management Consultants). 2021. Participatory Fish Study: Quarterly Report April–June 2021.

ERM/EMC (Environmental Resources Management and Environmental Management Consultants). 2018. Liza Phase 1 Enhanced Coastal Sensitivity Mapping – Ecosystem Services.

Minority Rights Group International. 2018. World Directory of Minorities and Indigenous Peoples – Guyana: Indigenous Peoples.

PAC (Protected Areas Commission). 2014. Shell Beach Protected Area Management Plan, 2015-2019.

Rhodius, Tiffany. 2020. “Indigenous Venezuelan migrants find refuge in Region One: The effects of the economic situation in Venezuela has affected all its people.” UNICEF: Guyana & Suriname. 19 February 2020. Accessed October 2021. Retrieved from: https://www.unicef.org/guyanasuriname/stories/indigenous-venezuelan-migrants-find-refuge-region-one

Chapter 9 Assessment and Mitigation of Potential Impacts from Unplanned Events

Section 9.1 Introduction

Albers, P.H. 1979. Effects of Corexit 9527 on the hatchability of mallard eggs. *Bulletin of Environmental Contamination and Toxicology*, 23, No. 4/5, pp. 661-668.

Alexander F.J., C.K. King, A.J. Reichelt-Brushett, and P.L. Harrison. 2017. Fuel Oil and Dispersant Toxicity to the Antarctic Sea Urchin (*Sterechinus neumayeri*). *Environmental Toxicology and Chemistry*, 36, No. 6, pp. 1563-1571.

AMSA (Australian Maritime Safety Authority). 2013. National Plan: List of Oil Spill Control Agents.

Ballou, T.G., S.C. Hess, R.E. Dodge, A.H. Knap, and T.D. Sleeter. 1989. Effects of Untreated and Chemically Dispersed Oil on Tropical Marine Communities: a Long-term Field Experiment. *International Oil Spill Conference Proceedings*, 1989, No. 1, pp. 447-454.

Bonn Agreement. 2007. Current Status of the BAOAC (Bonn Agreement Oil Appearance Code. Accessed: July 2021. Retrieved from: http://www.bonnagreement.org/site/assets/files/3951/0202_nl_current-status-of-the-baoac.doc

BSEE (Bureau of Safety and Environmental Enforcement). 2016. Worst Case Discharge Analysis (Volume I, February 2016).

Burns, K.A., S.D. Garrity, D. Jorissen, J. MacPherson, M. Stoelting, J. Tierney, and L. Yelle-Simmons. 1994. “The Galeta Oil Spill. II. Unexpected Persistence of Oil Trapped in Mangrove Sediments.” *Estuarine, Coastal and Shelf Science*, 38, No. 4, pp. 349-364.

Calleson, C. Scott, and R. Kipp Frohlich. 2007. REVIEW: Slower boat speeds reduce risks to manatees. *Endangered Species Research*, Vol. 3. 295-304. Accessed: July 2021. Retrieved from: https://www.researchgate.net/publication/240809975_REVIEW_Slower_boat_speeds_reduce_risks_to_manatees

Challenger, G., and G. Mauseth. 2011. Chapter 32 - Seafood Safety and Oil Spills. *Oil Spill Science and Technology*. F. Mervin (ed.). pp. 1083-1100.

Corredor, J.E., J.M. Morell, and C.E. Del Castillo. 1990. Persistence of Spilled Crude Oil in a Tropical Intertidal Environment. *Marine Pollution Bulletin*, 21, No. 8, pp. 385-388.

Davis, H.K., C.F. Moffat, and N.J. Shepherd. 2002. Experimental Tainting of Marine Fish by Three Chemically Dispersed Petroleum Products, with Comparisons to the *Braer* Oil Spill. *Spill Science & Technology Bulletin*. 7, No. 5-6, pp. 257-278.

De Stephanis, R., and E. Urquiola. 2006. Collisions between ships and cetaceans in Spain. Paper SC/58/BC5 presented to the IWC Scientific Committee.

DeMicco, E., P.A. Schuler, T. Omer, and B. Baca. 2011. Net Environmental Benefit Analysis (NEBA) of Dispersed Oil on Nearshore Tropical Ecosystems: Tropics-the 25th Year Research Visit. *International Oil Spill Conference*, 2011, No. 1, pp. abs282.

Dicks, B. 1998. The Environmental Impact of Marine Oils Spills—Effects, Recovery and Compensation. Paper presented at the International Seminar on Tanker Safety, Pollution Prevention, Spill Response and Compensation, August 2021, Rio de Janeiro, Brazil. Accessed: May 2018. Retrieved from: https://1library.net/document/zw1w4jgq-environmental-impact-marine-oil-spills-effects-recovery-compensation.html

Duke, N.C., K.A. Burns, and R.P.J. Swannell. 1999. Research into the Bioremediation of Oil Spills in Tropical Australia: with Particular Emphasis on Oiled Mangrove and Salt Marsh Habitat. Final Report to the Australian Maritime Safety Authority. Australian Institute of Marine Science.

Edgar, G.J., and N.S. Barrett. 2000. Impact of the *Iron Baron* oil spill on Subtidal Reef Assemblages in Tasmania. *Marine Pollution Bulletin*, 40, No. 1, pp. 36-49.

Eastin Jr., W.C., and B.A. Rattner. 1982. Effects of Dispersant and Crude Oil Ingestion on Mallard Ducklings (*Anas playyrhynchos*). *Bulletin of Environmental Contamination and Toxicology*, 29, No. 3, pp. 273-278.

Finch, B.E., K.J. Wooten, D.R. Faust, and P.N. Smith. 2012. Embryotoxicity of Mixtures of Weathered Crude Oil Collected from the Gulf of Mexico and Corexit 9500 in Mallard Ducks (*Anas platyrhynchos*). *Science of The Total Environment*, 426, pp.155-159.

Fingas, M. 2011. Chapter 15 - Oil Spill Dispersants: A Technical Summary. *Oil Spill Science and Technology*. F. Mervin, (ed.). pp. 435-582.

Gagnon, M.M., and C. Rawson. 2011. Montara Well Release Monitoring Study S4A - Assessment of Effects on Timor Sea Fish. Curtin University, Perth, Australia. 208 pp.

GESAMP (Joint Group of Experts on the Scientific Aspects of Marine Environment Protection). 2014. Revised GESAMP Hazard Evaluation Procedures for Chemical Substances Carried by Ships, 2nd Edition. Accessed: July 2021. Retrieved from: http://www.gesamp.org/publications/revised-hazard-evaluation-procedure-2nd-edition

Getter, C.D., T.G. Ballou, and C.B. Koons. 1985. “Effects of Dispersed Oil on Mangroves Synthesis of a Seven-year Study.” *Marine Pollution Bulletin*, 16, No. 8, pp. 318-324.

Gohlke, J.M., D. Dzigbodi, M. Tipre, M. Leader, and T. Fitzgerald. 2011. “A Review of Seafood Safety after the Deepwater Horizon Blowout.” *Environmental Health Perspectives*, 119, No. 8, pp.1062-1069.

Government of Guyana. 2020. National Oil Spill Contingency Plan. Government of the Cooperative Republic of Guyana. Accessed: September 2021. Retrieved from: https://petroleum.gov.gy/documents/guyana-national-oil-spill-contingency-plan-august-2020

Hazel, J., I.R. Lawler, H. Marsh, and S. Robson. 2007. Vessel speed increases collision risk for the green turtle *Chelonia mydas*. *Endangered Species Research*, Vol. 3: 105–113, 2007. Accessed: July 2021. Retrieved from: https://pdfs.semanticscholar.org/775b/0518cb8a8a15eaf053fef021e33f211804f1.pdf

Hemmer, M.J., M.G. Barron, and R.M. Greene. 2011. “Comparative Toxicity of Eight Oil Dispersants, Louisiana Sweet Crude Oil (LSC), and Chemically Dispersed LSC to Two Aquatic Test Species.” *Environmental Toxicology and Chemistry*. 30, No. 10, pp. 2244-2252.

Holdway, D.A. 2002. “The Acute and Chronic Effects of Wastes Associated with Offshore Oil and Gas Production on Temperate and Tropical Marine Ecological Processes.” *Marine Pollution Bulletin*, 44 No. 3, pp. 185-203.

IMO (International Maritime Organization). 2012. 2012 Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants. Resolution MEPC.227(64). Adopted on 5 October 2012. Accessed: July 2021. Retrieved from: http://www.jodc.go.jp/jodcweb/info/ioc_doc/GESAMP/GESAMP64.pdf

ITOPF (International Tanker Owners Pollution Federation). 2013. Technical Information Paper 2—Fate of Marine Oil Spills. Accessed: May 2018. Retrieved from: https://www.itopf.org/fileadmin/uploads/itopf/data/Documents/TIPS_TAPS_new/TIP_2_Fate_of_Marine_Oil_Spills.pdf

_____. 2014. Technical Information Paper No. 13 – Effects of Oil Pollution on the Marine Environment. Accessed: July 2021. Retrieved from: https://www.itopf.org/fileadmin/uploads/itopf/data/Documents/TIPS_TAPS_new/TIP_13_Effects_of_Oil_Pollution_on_the_Marine_Environment.pdf

Jung, J.-H., M. Kim, U.H. Yim, S.Y. Ha, J.G. An, J.H. Won, G.M. Han, N.S. Kim, R.F. Addison, and W.J. Shim. 2011. Biomarker Responses in Pelagic and Benthic Fish over 1 Year following the *Hebei Spirit* Oil Spill (Taean, Korea). *Marine Pollution Bulletin*, 62 No. 8, pp. 1859-1866.

Kenworthy, W.J., M.J. Durako, S.M.R. Fatemy, H. Valavi, and G.W. Thayer. 1993. Ecology of Seagrasses in North Eastern Saudi Arabia One Year after the Gulf War Oil Spill. *Marine Pollution Bulletin*, 27, No. 1993, pp. 213-222.

Knowlton, A., and S. Kraus. 2001. Mortality and serious injury of northern right whales (*Eubalaena glacialis*) in the western North Atlantic Ocean. *Journal of Cetacean Research and Management* (Special Issue). Accessed: July 2021. Retrieved from: https://www.researchgate.net/publication/228995414_Mortality_and_serious_injury_of_northern_right_whales_Eubalaena_glacialis_in_the_western_North_Atlantic_Ocean

Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, and M. Podesta. 2001. Collisions between Ships and Whales. *Marine Mammal Science*, 17(1):35–75. January 2001. Accessed: July 2021. Retrieved from: http://cpps.dyndns.info/cpps-docs-web/planaccion/docs2013/ago/transfront/Laist-et-al-2001.pdf

Laist, D.W., and C. Shaw. 2006. Preliminary Evidence that Boat Speed Restrictions Reduce Deaths of Florida Manatees. *Marine Mammal Science*, 22(2): 472–479. April 2006. Accessed: July 2021. Retrieved from: https://www.mmc.gov/wp-content/uploads/laist2006.pdf

Law, R.J., C.A. Kelly, K.L. Graham, R.J. Woodhead, P.E.J. Dyrynda, and E.A. Dyrynda. 1997. "Hydrocarbons and PAH in Fish and Shellfish from Southwest Wales Following the *Sea Empress* Oil Spill in 1996." *International Oil Spill Conference Proceedings*, 1997, No. 1, pp. 205-211.

Lee, K., T. King, B. Robinson, Z. Li, L. Burridge, M. Lyons, D. Wong, K. MacKeigan, S. Courtenay, S. Johnson, M. Boudreau, P. Hodson, C. Greer, and A. Venosa. 2011. "Toxicity Effects of Chemically-Dispersed Crude Oil on Fish." *International Oil Spill Conference Proceedings*, 2011, No. 1, pp. abs163.

Lobón, C.M., C. Fernández, J. Arrontes, J.M. Rico, J.L. Acuña, R. Anadón, and J.A. Monteoliva. 2008. "Effects of the 'Prestige' oil spill on macroalgal assemblages: Large-scale comparison." *Marine Pollution Bulletin* 56(6):1192-1200.

NRC (National Research Council). 2005. Oil Spill Dispersants: Efficacy and Effects (2005). Accessed: July 2021. Retrieved from: https://www.nap.edu/read/11283/chapter/1#xii

Peakall, D.B., P.G. Wells, and D. Mackay. 1987. "A Hazard Assessment of Chemically Dispersed Oil Spills and Seabirds." *Marine Environmental Research*, 22, No. 2, pp. 91-106.

Peckol, P., S.C. Levings, and S.D. Garrity. 1990. Kelp Response Following the *World Prodigy* Oil Spill. *Marine Pollution Bulletin*, 21, No. 10, pp. 473-476.

Rainer Engelhardt, F. 1983. Petroleum Effects on Marine Mammals. *Aquatic Toxicology*, 4, No. 3, pp. 199-217.

Rawson, C., M.M. Gagnon, and H. Williams. 2011. Montara Well Release: Olfactory Analysis of Timor Sea Fish Fillets. Curtin University, Perth, Western Australia. 18 pp.

RPS. 2018a. OILMAPDEEP: Deep Water Oil Spill Model and Analysis System. Accessed: July 2021. Retrieved from: http://www.asascience.com/software/oilmap/oilmapdeep.shtml

_____. 2018b. SIMAP: Integrated Oil Spill Impact Model System. Accessed: July 2021. Retrieved from: http://asascience.com/software/simap/

_____. 2019. ExxonMobil Offshore Guyana, Payara Prospect. 18-P-201703. Oil Spill Risk Assessment. 27 April 2019.

RPS. 2021. ExxonMobil Guyana Yellowtail Oil Spill Modeling Analysis, 21-P-214165: Oil Spill Risk Assessment.

Rycyk, A.M., C.J. Deutsch, M.E. Barlas, S.K. Hardy, K. Frisch, E.H. Leone, and D.P. Nowacek. 2018. Manatee behavioral response to boats. *Marine Mammal Science*, 34: 924-962. Accessed: July 2021. Retrieved from: https://onlinelibrary.wiley.com/doi/full/10.1111/mms.12491

Sadaba, R.B., and A.P. Barnuevo. 2011. "Monitoring of the impacts, responses, and recovery of mangroves affected by M/T Solar I oil spill in Guimaras, Philippines." *International Oil Spill Conference Proceedings*, 2011, No. 1, p. 398.

Shigenaka, G. 2011. “Chapter 27 Effects of Oil in the Environment.” *Oil Spill Science and Technology*, F. Mervin, (ed.). pp. 985-1024.

St. Aubin, D.J., and V. Lounsbury. 1990. “Chapter 11 - Oil Effects on Manatees: Evaluating the Risks.” *Sea Mammals and Oil: Confronting the Risks*. G. Joseph (ed.). pp. 241-251: Academic Press.

Taylor, H.A., and M.A. Rasheed. 2011. “Impacts of a Fuel Oil Spill on Seagrass Meadows in a Subtropical Port, Gladstone, Australia – The Value of Long-term Marine Habitat Monitoring in High Risk Areas.” *Marine Pollution Bulletin*, 63, No. 5–12, pp. 431-437.

Teal, J.M., J.W. Farrington, K.A. Burns, J.J. Stegeman, B.W. Tripp, B. Woodin, and C. Phinney. 1992. “The West Falmouth Oil Spill after 20 years: Fate of Fuel Oil Compounds and Effects on Animals.” *Marine Pollution Bulletin*, 24, No. 12, pp. 607-614.

Thorhaug, A., and J. Marcus. 1987. “Oil Spill Clean-up: The Effect of Three Dispersants on Three Subtropical/Tropical Seagrasses.” *Marine Pollution Bulletin*, 18, No. 3, pp. 124-126.

Vanderlaan, A.S.M., and C.T. Taggart. 2007. Vessel Collisions with Whales: The Probability of Lethal Injury Based on Vessel Speed. *Marine Mammal Science*, 23(1): 144–156. January 2007. Accessed: July 2021. Retrieved from: https://www.phys.ocean.dal.ca/~taggart/Publications/Vanderlaan_Taggart_MarMamSci-23_2007.pdf

Ward, G.A., B. Baca, W. Cyriacks, R.E. Dodge, and A. Knap. 2003. “Continuing Long-Term Studies of the Tropics Panama oil and Dispersed Oil Spill Sites.” *International Oil Spill Conference Proceedings*, 2003, No. 1, pp. 259-267.

Wardrop, J. 1987. “The Effects of Oil and Dispersants on Mangroves: a Review and Bibliography.” Vol., No. 2, pp. 49-70. Adelaide: Centre for Environmental Studies, University of Adelaide.

Wilson, K.G., and P.J. Ralph. 2012. “Laboratory testing protocol for the impact of dispersed petrochemicals on seagrass.” *Marine Pollution Bulletin.* 64(11):2421-2427

Wirsing, A.J., R. Abernethy, and M.R. Heithaus. 2008. Speed and Maneuverability of Adult Loggerhead Turtles (Caretta Caretta) under Simulated Predatory Attack: Do the Sexes Differ? *Journal of Herpetology.* 42, no. 2: 411-13. Accessed: July 2021. Retrieved from: www.jstor.org/stable/40060528

Wetzel, D.L., and E.S. Van Fleet. 2001. “Cooperative Studies on the Toxicity of Dispersants and Dispersed Oil to Marine Organisms: a 3-year Florida Study.” *International Oil Spill Conference Proceedings*. No. 2, pp. 1237-1241.

Section 9.2 Air Quality, Climate, and Climate Change

Gros, Jonas, Nabi, Deedar; Würz, Birgit; Wick, Lukas; Brussaard, Corina; Huisman, Johannes; Meer, Jan; Reddy, Christopher; and Arey, J. 2014. :First Day of an Oil Spill on the Open Sea: Early Mass Transfers of Hydrocarbons to Air and Water.” Environmental Science & Technology. 48. 10.1021/es502437e.

Malins, Chris, Stephanie Searle, Nikita Pavlenko. 2015. *Assessment of the scale of potential indirect emissions due to higher oil use*. International Council on Clean Transportation. White Paper, October 2015. Accessed: September 2021. Retrieved from: https://theicct.org/sites/default/files/publications/Indirect_emissions_%20oil_use_201510.pdf

Middlebrook, A. M., Murphy, D. M., Ahmadov, R., Atlas, E. L., Bahreini, R., Blake, D. R., Brioude, J., de Gouw, J. A., Fehsenfeld, F. C., Frost, G. J., Holloway, J. S., Lack, D. A., Langridge, J. M., Lueb, R. A., McKeen, S. A., Meagher, J. F., Meinardi, S., Neuman, J. A., Nowak, J. B., Parrish, D. D., and Ravishankara, A. R. 2012. Air quality implications of the Deepwater Horizon oil spill. Proceedings of the National Academy of Sciences of the United States of America, 109(50), 20280–20285. https://doi.org/10.1073/pnas.1110052108

National Academies of Sciences, Engineering, and Medicine. 2016. *Spills of Diluted Bitumen from Pipelines: A Comparative Study of Environmental Fate, Effects, and Response*. Washington, DC: The National Academies Press.

Section 9.3 Marine Geology and Sediments

Brooks, G.R., R.A. Larson, P.T. Schwing, I. Romero, C. Moore, G. Reichart, T. Jilbert, J.P. Chanton, D.W. Hastings, W.A. Overholt, K.P. Marks, J.E. Kostka, C.W. Holmes, and D. Hollander. 2015. "Sedimentation Pulse in the NE Gulf of Mexico following the 2010 DWH Blowout." PLoS One. 2015; 10(7): e0132341. DOI:10.1371/journal.pone.0132341

Joye, S.B., A. Bracco, T.M. Özgökmen, J.P. Chanton, M. Grosell, I.R. MacDonald, E.E. Cordes, J.P. Montoya, and U. Passow. 2016. "The Gulf of Mexico ecosystem, six years after the Macondo oil well blowout" Deep-Sea Research II 129 (2016) 4–19

NOAA (National Oceanographic and Atmospheric Administration, Office of Response and Restoration). 2020. Small Diesel Spills (500-5,000 gallons). Accessed: August 2020. Retrieved from: https://response.restoration.noaa.gov/sites/default/files/Small-Diesel-Spills.pdf

Reuscher, M.G., J.G. Baguley, and P.A. Montagna. 2020. “The expanded footprint of the Deepwater Horizon oil spill in the Gulf of Mexico deep-sea benthos.” PLOS ONE 15(6): e0235167. https://doi.org/10.1371/journal.pone.0235167

Vad, J., G. Kazanidis, L. Henry, D.O.B. Jones, O.S. Tendal, S. Christiansen, T.B. Henry, J.M. Roberts. 2018. "Chapter Two - Potential Impacts of Offshore Oil and Gas Activities on Deep-Sea Sponges and the Habitats They Form." *Advances in Marine Biology*, Vol. 79. 2018. Pp 33-60. Academic Press.

Section 9.4 Marine Water Quality

IMO (International Maritime Organization). 2012. Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants. Annex 22. Resolution MEPC.227(64). Adopted on 5 October 2012. MEPC 64/23.

ITOPF (International Tanker Owners Pollution Federation). 2014. Effects of Oil Pollution on the Marine Environment. Technical Information Paper No. 13. Accessed: July 2021. Retrieved from: https://www.itopf.org/fileadmin/uploads/itopf/data/Documents/TIPS_TAPS_new/TIP_13_Effects_of_Oil_Pollution_on_the_Marine_Environment.pdf

Section 9.5 Protected Areas and Special Status Species

IMO (International Maritime Organization). 2012. Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants. Annex 22. Resolution MEPC.227(64). Adopted on 5 October 2012. MEPC 64/23.

IUCN (International Union for Conservation of Nature). 2021. IUCN Red List of Threatened Species Version 2021-1. Accessed: July 2021. Retrieved from: http://www.iucnredlist.org/

Yuewen D., and L. Adzigbli. 2018. “Assessing the Impact of Oil Spills on Marine Organisms.” *Journal of Oceanography and Marine Research*. 6: 179. doi:10.4172/2572-3103.1000179. Accessed: September 2021. Retrieved from: https://www.longdom.org/open-access/assessing-the-impact-of-oil-spills-on-marine-organisms-2572-3103-1000179.pdf

Zima, P.V., and M.R. Francisco. 2016. Reproductive Behavior of the Red-crested Finch *Coryphospingus cucullatus* (Aves: Thraupidae) in Southeastern Brazil. *Zoologia* (Curitiba), 33.

Section 9.6 Coastal Habitats

Hayashi S.N., P.W.M. Souza-Filho, W.R. Nascimento Jr., and M.E.B. Fernandes. 2019. The effect of anthropogenic drivers on spatial patterns of mangrove land use on the Amazon coast. *PLoS ONE.* 14(6): e0217754. https://doi.org/10.1371/journal.pone.0217754

ITOPF (International Tanker Owners Pollution Federation). 2014. Effects of Oil Pollution on the Marine Environment. Technical Information Paper No. 13. Accessed: July 2021. Retrieved from: https://www.itopf.org/fileadmin/uploads/itopf/data/Documents/TIPS_TAPS_new/TIP_13_Effects_of_Oil_Pollution_on_the_Marine_Environment.pdff

Toorman, E. A., E. Anthony, P.G. Augustinus, A. Gardel, N. Gratiot, O. Homenauth, N. Huybrechts, J. Monbaliu, K. Moseley, and S. Naipa. 2018. Interaction of mangroves, coastal hydrodynamics, and morphodynamics along the coastal fringes of the Guianas. In Threats to Mangrove Forests (pp. 429-473). Springer, Cham.

Section 9.7 Coastal Wildlife

Da Silva, E.M., M.C. Peso-Aguiar, M. De Fátima Teixeira Navarro, and C. De Barros E Azevedo Chastinet. 1997. “Impact of Petroleum Pollution on Aquatic Coastal Ecosystems in Brazil”. *Environmental Toxicology and Chemistry: An International Journal*. 16(1), 112-118.

ERM (Environmental Resources Management). 2021. 2nd Year Fisheries Summary Report, June 2021.

French-McCay, D. 2009. State-of-the-Art and Research Needs for Oil Spill Impact Assessment Modeling. In *Proceedings of the 32nd AMOP Technical Seminar on Environmental Contamination and Response, Emergencies Science Division, Environment Canada, Ottawa, ON, Canada* (pp. 601-653). June.

Winterwerp, J.C., T. Albers, E.J. Anthony, D.A. Friess, A.G. Mancheño, K. Moseley, and B.K. Van Wesenbeeck. 2020. Managing Erosion of Mangrove-mud Coasts with Permeable Dams–Lessons Learned. *Ecological Engineering*, 158, 106078.

Zima, P.V., and M.R. Francisco. 2016. Reproductive Behavior of the Red-crested Finch *Coryphospingus cucullatus* (Aves: Thraupidae) in Southeastern Brazil. *Zoologia* (Curitiba), 33.

Section 9.8 Seabirds

Finch, B.E., K.J. Wooten, and P.N. Smith. 2011. Embryotoxicity of Weathered Crude Oil from the Gulf of Mexico in Mallard Ducks (*Anas platyrhynchos*). *Environ. Toxicol. Chem*. 30(8):1885-91. doi: 10.1002/etc.576. Epub 2011 Jun 8.

Henkel, J.R., B.J. Sigel, and C.M. Taylor. 2012. “Large-Scale Impacts of the Deepwater Horizon Oil Spill: Can Local Disturbance Affect Distant Ecosystems through Migratory Shorebirds?” *BioScience*. Volume 62, Issue 7, Pp. 676–685. Accessed: July 2021. Retrieved from: http://jessicahenkel.com/wp-content/uploads/2011/06/bio201262711_Forum_Henkel1.pdf

IMO (International Maritime Organization). 2012. Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants. Annex 22. Resolution MEPC.227(64). Adopted on 5 October 2012. MEPC 64/23.

La Sorte, F. A., Fink, D., Hochachka, W. M., & Kelling, S. (2016). Convergence of broad-scale migration strategies in terrestrial birds. Proceedings of the Royal Society B: Biological Sciences, 283(1823)

Maggini, I., L. Kennedy, A. Macmilan, K. Elliott, K. Dean, and C. Guglielmo 2017. “Light Oiling of Feathers Increases Flight Energy Expenditure in a Migratory Shorebird.” *Journal of Experimental Biology.* 220: 2372-2379. doi:10.1242/jeb.158220

Matcott, J., S. Baylis, and R. H. Clarke. 2019. “The influence of petroleum oil films on the feather structure of tropical and temperate seabird species.” *Marine Pollution Bulletin* 138: 135-144. doi.org/10.1016/j.marpolbul.2018.11.010

Morandin, L., and P. D. O’Hara. 2016. “Offshore oil and gas, and operational sheen occurance: is there potential harme to marine birds?” *Environmental Reviews*. 24: 285-318. doi.org/10.1139/er-2015-0086

Troisi GM, Bexton, S, and I. Robinson. 2006. “Polyaromatic Hydrocarbon and PAH Metabolite Burdens in Oiled Common Guillemots (Uria aalge) Stranded on the East Coast of England (2001-2002).” *Environmental Science and Technology.* 40: 7938e45.

Troisi, G., S. Barton, and S. Bexton. 2016. ‘Impacts of Oil Spills on Seabirds: Unsustainable Impacts of Non-Renewable Energy.” *International Journal of Hydrogen Energy.* 41: 16549-16555.

Walter, S. T., M.R. Carloss, T.J. Hess, and P.L. Leberg. 2014. “Demographic trends of Brown Pelicans in Louisiana before and after the Deepwater Horizon oil spill.” *Journal of Field Ornithology*. 85(4), 421-429.

Whitmer, E., B. Elias, D. Harvey, and M. Ziccardi. 2018. “An Experimental Study of the Effects of Chemically Dispersed Oil on Feather Structure and Waterproofing in Common Murres (Uria aalge).” *Journal of Wildlife Diseases*. 54, no. 2: 315–328.

Wiens, J. 1995 "Recovery of Seabirds Following the Exxon Valdez Oil Spill: An Overview," *Exxon Valdez Oil Spill: Fate and Effects in Alaskan Waters*. Ed. P. Wells, J. Butler, and J. Hughes (West Conshohocken, PA: ASTM International, 1995), 854 893. https://doi.org/10.1520/STP19883S

_____. 1996. “Oil, Seabirds, and Science.” *BioScience.* 46, no.8: 587-597.

Section 9.9 Marine Mammals

Helm, R.C., D.P. Costa, T.D. DeBruyn, T.J. O’Shea, R.S. Wells, and T.M. Williams. 2015. “Overview of effects of oil spills on marine mammals.” *Handbook of oil spill science and technology*. John Wiley & Sons, Hoboken, NJ, 455-475.

IMO (International Maritime Organization). 2012. Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants. Annex 22. Resolution MEPC.227(64). Adopted on 5 October 2012. MEPC 64/23.

Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, and M. Podesta. 2001. “Collisions between Ships and Whales.” *Marine Mammal Science.* 17, no.1: 35-75. Accessed: July 2021. Retrieved from: https://www.mmc.gov/wp-content/uploads/shipstrike.pdf

Mearns, A.J., D.J. Reish, M. Bissell, A.M. Morrison, M.A. Rempel-Hester, C. Arthur, and R. Pryor. 2018. “Effects of pollution on marine organisms.” *Water Environment Research*, 90(10), 1206-1300.

NRC (National Research Council). 1993. Managing Wastewater in Coastal Urban Areas. The National Academies Press. pp. 478.

Peel, D., J. Smith, and S. Childerhouse. 2018. “Vessel Strike of Whales in Australia: The Challenges of Analysis of Historical Incident Data.” *Front. Mar. Sci.* 5: 1-14.

Section 9.10 Riverine Mammals

Ackerman, B.B. 1995. Aerial Surveys of Manatees: A Summary and Progress Report. In: T.J. O'Shea, B.B. Ackerman and H.F. Percival (eds), Population Biology of the Florida Manatee. National Biological Service Information and Technology Report 1., pp. 13-33. Washington, DC, USA.

Aipanjiguly, S., S.K. Jacobson, and R. Flamm. 2003. "Conserving Manatees: Knowledge, Attitudes and Intentions of Boaters in Tampa Bay, Florida." *Conservation Biology.* 17, no. 4: 1098-1105.

Barnett, A., R. Shapley, S. Lehman, E. Henry, and P. Benjamin. 2000. "Records of the Giant Otter, *Pteronura brasiliensis*, from Guyana." IUCN Otter Specialist Group Bulletin, 17(2), 65-74.

de Jesus Lobo, A., L.L. Wedekin, T. Sobral-Souza, and Y. le Pendu. 2021. "Potential Distribution of Guiana Dolphin (*Sotalia guianensis*): a Coastal-estuarine and Tropical Habitat Specialist." *Journal of Mammology* 102(1): 308-318.

Deutsch, C.J., B.B. Ackerman, T.D. Pitchford, and S.A. Rommel. 2002. Trends in Manatee Mortality in Florida. Manatee Population Ecology and Management Workshop, Gainesville, Florida, USA.

Deutsch, C.J., and J.E. Reynolds III. 2012. Florida Manatee Status and Conservation Issues: A Primer. Pages 23–35 in E.M. Hines, J.E. Reynolds III, L.V. Aragones, A.A. Mignucci-Giannoni, and M. Marmontel, eds. *Sirenian Conservation: Issues and Strategies in Developing Countries.* University Press of Florida, Gainesville, FL.

Edwards, H.H., J. Martin, C.J. Deutsch, R.G. Muller, S.M. Koslovsky, A.J. Smith, and M.E. Barlas. 2016. "Influence of Manatees' Diving on Their Risk of Collision with Watercraft." *PLoS ONE*. 11(4): e0151450. doi:10.1371/journal.pone.0151450.

EPA et al. (Guyana Environmental Protection Agency et al.). 2004. Shell Beach Protected Area Rapid Biodiversity Assessment. August-October 2004.

Fingas, M. 2015. Handbook of Oil Spill Science and Technology. John Wiley and Sons, Inc. Publishers. Hoboken, New Jersey. 692 pp.

Helm, R.C., D.P. Costa, T.D. DeBruyn, T.J. O'Shea, R.S. Wells, and T.M. Williams. 2015. "Overview of Effects of Oil Spills on Marine Mammals." *Handbook of Oil Spill Science and Technology*. John Wiley & Sons, Hoboken, NJ, 455-475.

IUCN (International Union for Conservation of Nature). 2021. 2021 Red List of Threatened Species Version 2021.1. Accessed: July 2021. Retrieved from: http://www.iucnred list.org/

Mendonca, S., M. Kalamandeen, and R.S. McCall. 2006. A Bird's Eye View: Coastal Birds of Shell Beach. Proceedings of International Conference on the Status of Biological Sciences in Caribbean and Latin American Societies.

Nowacek, S.M., R. Wells, E.C.G. Owen, T. Speakman, R.O. Flamm, and D.P. Nowacek. 2004. "Florida Manatees, *Trichechus manatus latirostris*, Respond to Approaching Vessels." *Biological Conservation*. vol. 119, no. 4, pp. 517-523.

Runge M.C., C.A. Sanders-Reed, C.A. Langtimm, and C.J. Fonnesbeck. 2007. A Quantitative Threats Analysis for the Florida Manatee (*Trichechus manatus latirostris*). U.S. Geological Survey Open-File Report 2007: p 108634.

Rycyk, A., C. Deutsch, M. Barlas, S. Hardy, K. Frisch, E. Leone, and D. Nowacek. 2018. Manatee Behavior Response to Boats. *Marine Mammal Science*. 34(4): 924-962.

Section 9.11 Marine Turtles

Alvarez-Varas, R., R. Berzins, K. Bilo, J. Chevalier, C. Damien, B. Thoisy, A. Fallabrino, M. Garcia Cruz, S. Kelez, M. Lopez-Mendilharsu, M. Marcovaldi, R. Mast, C. Medrano, C. Miranda, M.A. Nalovic, L. Prosdocimi, J.M. Rguez-Baron, A. Santos, L. Soares, and G. Velez-Rubio. 2016. "Sea Turtles of South America." Chapter in book: *States of the World's Sea Turtles*. SWOT. Accessed: July 2021. Retrieved from: https://www.researchgate.net/publication/298068843_Sea_Turtles_of_South_America

Denkinger, J., M. Parra, J.P. Muñoz, C. Carrasco, J.C. Murillo, E. Espinosa, F. Rubianes, and V. Koch. 2013. Are Boat Strikes a Threat to Sea Turtles in the Galapagos Marine Reserve? *Ocean & Coastal Management*. 80: 29-35.

Frasier, K.E., A. Solsona-Berga, L. Stokes, and J.A. Hildebrand. 2020. Impacts of the Deepwater Horizon Oil Spill on Marine Mammals and Sea Turtles. In Deep Oil Spills (pp. 431-462). Springer, Cham.

Hazel, J., I.R. Lawler, H. Marsh, and S. Robson. 2007. Vessel Speed Increases Collision Risk for the Green Turtle *Chelonia mydas*. *Endangered Species Research*, Vol. 3: 105–113, 2007. Accessed: July 2021. Retrieved from: https://pdfs.semanticscholar.org/775b/0518cb8a8a15eaf053fef021e33f211804f1.pdf

IMO (International Maritime Organization). 2012. Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants. Annex 22. Resolution MEPC.227(64). Adopted on 5 October 2012. MEPC 64/23.

Mitchelmore, C.L., C.A. Bishop, and T.K. Collier. 2017. "Toxicological Estimation of Mortality of Ocean Sea Turtles Oiled During the *Deepwater Horizon* Oil Spill." *Endangered Species Research*. vol. 33: 39-50, 2017. doi: 0.3354/esr00758.

NOAA (National Oceanic and Atmospheric Administration). 2010. Oil and Sea Turtles: Biology, Planning, and Response. 116 pp.

Ruberg E.J., T.D. Williams, and J.E. Elliott. 2021. "Review of Petroleum Toxicity in Marine Reptiles." *Ecotoxicology*. 30(4):525-536. doi:10.1007/s10646-021-02359-9

Schuyler, Q., B.D. Hardesty, C. Wilcox, and K. Townsend. 2012. "To Eat or Not to Eat? Debris Selectivity by Marine Turtles." *PLoS ONE.* 7(7): e40884. Retrieved from: https://doi.org/10.1371/journal.pone.0040884

Shaver, D.J., C. Gredzens, J.S. Walker, C.A. Godard-Codding, J.E. Yacabucci, A. Frey, and C.J. Schmitt. 2021. Embryo Deformities and Nesting Trends in Kemp's Ridley Sea Turtles *Lepidochelys kempii* Before and After the Deepwater Horizon Oil Spill. *Endangered Species Research*, 44, 277-289.

USFWS (U.S. Fish and Wildlife Service). 1982. Effects of Petroleum on the Development and Survival of Marine Turtle Embroyos. FWS/OBS-82/37. 50 pp.

Wallace, B.P., T. Brosnan, D. McLamb, T. Rowles, E. Ruder, B. Schroeder, and D. Wehner. 2017. Effects of the Deepwater Horizon Oil Spill on Protected Marine Species. *Endangered Species Research*, 33, 1-7.

Wallace, B.P., B. Stacy, E. Cuevas, C. Holyoake, P. Lara, A. Marcondes, Jeffrey D. Miller, H. Nijkamp, N. Pilcher, I. Robinson, N. Rutherford, and G. Shigenaka. 2020. "Oil Spills and Sea Turtles: Documented Effects and Considerations for Response and Assessment Efforts." *Endangered Species Research* 41: 17-37. Accessed: September 2021. Retrieved from: https://pdfs.semanticscholar.org/8716/d8da738b8fd3fe1ba3bf38a3d769885153ea.pdf?_ga=2.154105208.1918588.1632144815-1115495585.1622993134

Wirsing, A.J., R. Abernethy, and M.R. Heithaus. 2008. Speed and Maneuverability of Adult Loggerhead Turtles (*Caretta Caretta*) under Simulated Predatory Attack: Do the Sexes Differ? *Journal of Herpetology.* 42, no. 2: 411-13. Accessed: July 2021. Retrieved from: www.jstor.org/stable/40060528

Yender, R.A., and A.J. Mearns. 2003. Case Studies of Spills that Threaten Sea Turtles. Oil and Sea Turtles: Biology, Planning, and Response. NOAA, National Ocean Service, Office of Response and Restoration, Seattle, Washington, 69-86.

Section 9.12 Marine Fish

Cowen, R.K., K.M.M. Lwiza, S. Sponaugle, C.B. Paris, and D.B. Olson. 2000. "Connectivity of Marine Populations: Open or Closed?" *Science* 287, 857; doi: 10.1126/science.287.5454.857

de Freitas, D.M., and J.H. Muelbert. 2004. "Ichthyoplankton Distribution and Abundance off Southeastern and Southern Brazil." *Braz. arch. biol. technol*. vol.47 no.4. ISSN 1678-4324.

Habtes, S., F.E. Muller-Karger, M.A. Roffer, J.T. Lamkin, and B.A.A. Muhling. 2014. "Comparison of Sampling Methods for Larvae of Medium and Large Epipelagic Fish Species During Spring SEAMAP Ichthyoplankton Surveys in the Gulf of Mexico." Published in *Limnology and Oceanographic Methods*. 2014.

IMO (International Maritime Organization). 2012. Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants. Annex 22. Resolution MEPC.227(64). Adopted on 5 October 2012. MEPC 64/23.

ITOPF (International Tanker Owners Pollution Federation). 2014. Effects of Oil Pollution on the Marine Environment. Technical Information Paper No. 13. Retrieved from: https://www.itopf.org/fileadmin/uploads/itopf/data/Documents/TIPS_TAPS_new/TIP_13_Effects_of_Oil_Pollution_on_the_Marine_Environment.pdf

MBC (MBC Applied Environmental Sciences). 2011. Life History Parameters of Common Southern California Marine Fishes. Prepared for the California Energy Commission Public Interest Energy Research Program. Accessed: July 2019. Retrieved from: https://babel.hathitrust.org/cgi/pt?id=uc1.31822036832384&view=1up&seq=15

National Research Council. 1993. Managing Wastewater in Coastal Urban Areas. The National Academies Press. pp. 478.

NOAA (U.S. National Oceanic and Atmospheric Administration). 2015. How Oil Damages Fish Hearts: Five Years of Research Since the Deepwater Horizon Oil Spill. Accessed: July 2021. Retrieved from: https://www.fisheries.noaa.gov/feature-story/how-oil-damages-fish-hearts-five-years-research-deepwater-horizon-oil-spill

USEPA (U.S. Environmental Protection Agency). 2010. Comparative Toxicity of Eight Oil Dispersant Products on Two Gulf of Mexico Aquatic Test Species. Accessed: July 2021. Retrieved from: https://archive.epa.gov/emergency/bpspill/web/pdf/comparativetoxtest.final.6.30.10.pdf

Section 9.13 Marine Benthos

Blackburn, M., C.A.S. Mazzacano, C. Fallon, and S.H. Black. 2014. Oil in our Oceans, A Review of the Impacts of Oil Spills on Marine Invertebrates. 152 pp. Portland, Oregon: The Xerces Society of Invertebrate Conservation. Accessed: July 2021. Retrieved from: http://xerces.org/sites/default/files/2018-05/14-003_01_XercesSoc_Oil-in-Our-Oceans_web.pdf

Brooks, G.R., R.A. Larson, P.T. Schwing, I. Romero, C. Moore, G. Reichart, T. Jilbert, J.P. Chanton, D.W. Hastings, W.A. Overholt, K.P. Marks, J.E. Kostka, C.W. Holmes, and D. Hollander. 2015. “Sedimentation Pulse in the NE Gulf of Mexico Following the 2010 DWH Blowout.” *PLoS One*. 2015; 10(7): e0132341. DOI:10.1371/journal.pone.0132341

Fisher, C.R., P.-Y. Hsing, C.L. Kaiser, D.R. Yoerger, H.H. Roberts, W.W. Shedd, E.E. Cordes, T.M. Shank, S.P. Berlet, M.G. Saunders, E.A. Larcom, and J.M. Brooks. 2014. Footprint of Deepwater Horizon Blowout Impact to Deep-water Coral Communities. Proceedings of the National Academy of Sciences 12 August 2014 111 (32) 11744-11749; first published 28 July 2014. Accessed: July 2021. Retrieved from: https://doi.org/10.1073/pnas.1403492111

IOGP (International Association of Oil and Gas Producers). 2016. Environmental Fates and Effects of Ocean Discharge of Drill Cuttings and Associated Drilling Fluids from Offshore Oil and Gas Operations. Accessed: July 2021. Retrieved from: http://www.iogp.org/pubs/543.pdf

Joye, S.B., A. Bracco, T. M. Özgökmen, J.P. Chanton, M. Grosell, I.R. MacDonald, E.E. Cordes, J.P. Montoya, and U. Passow. 2016. “The Gulf of Mexico Ecosystem, Six Years after the Macondo Oil Well Blowout.” *Deep-Sea Research* II 129 (2016) 4–19.

Montagna, P.A., J.G. Baguley, C. Cooksey, and J.L. Hyland. 2013. Deepwater Horizon Oil Spill: Assessment of Potential Impacts on the Deep Soft-Bottom Benthos. Interim Data Summary Report. NOAA Technical Memorandum NOS NCCOS 166. NOAA, National Centers for Coastal Ocean Science, Charleston, SC. 32 pp.

NOAA (National Oceanographic and Atmospheric Administration). 2020. Small Diesel Spills (500-5,000 gallons). NOAA Office of Response and Restoration. Accessed: August 2020. Retrieved from: https://response.restoration.noaa.gov/sites/default/files/Small-Diesel-Spills.pdf

Reuscher, M.G., J.G. Baguley, P.A. Montagna. 2020. “The Expanded Footprint of the Deepwater Horizon Oil Spill in the Gulf of Mexico Deep-sea Benthos.” *PLOS ONE* 15(6): e0235167. https://doi.org/10.1371/journal.pone.0235167

Section 9.14 Ecological Balance and Ecosystems

Armengol, L., A. Calbet, G. Franchy, A. Rodriguez-Santos, and S. Hernandez-Leon. 2019. “Planktonic Food Web Structure and Trophic Transfer Efficiency along a Productivity Gradient in the Tropical and Subtropical Atlantic Ocean.” *Scientific Reports* 9:2044.

Aslan, J.F., L.I. Weber, J. Iannacone, J.L. Junior, V.B. Saraiva, and M.M. Oliveira. 2019. “Toxicity of Drilling Fluids in Aquatic Organisms: a Review.” *Ecotoxicology and Environmental Contamination*, 14(1), 35-47.

Chanton, J.P., J. Cherrier, R.M. Wilson, J. Sarkodee-Adoo, S. Bosman, A. Mickle, and W.M. Graham. 2012. “Radiocarbon Evidence that Carbon from the Deepwater Horizon Spill Entered the Planktonic Food Web of the Gulf of Mexico.” *Environmental Research Letters*, (7) 4.

Garcia, J.V., E. Zamora-Ledezma, and K. Aguilar. 2014. “Environmental Performance of Drilling Fluids Selected for Offshore Operations in Venezuela.” *World. Appl. Sci. J*, 29(10), 1310-1314.

GOMRI (Gulf of Mexico Research Initiative). 2015. Studies Identify Oil Spill Effects in Deep Sea Fish. Accessed: July 2021. Retrieved from: http://gulfresearchinitiative.org/studies-identify-oil-spill-effects-in-deep-sea-fish/

Jung, J-H., M. Kim, U.H. Yim, S.Y. Ha, J.G. An, J.H. Won, G.M. Han, N.S. Kim, R.F. Addison, and W.J. Shim. 2011. “Biomarker Responses in Pelagic and Benthic Fish over 1 Year following the Hebei Spirit Oil Spill (Taean, Korea).” *Marine Pollution Bulletin.* 62, no.8:1859-1866.

Law, R.J., C.A. Kelly, K.L. Graham, R.J. Woodhead, P.E.J. Dyrynda, and E.A. Dyrynda. 1997. "Hydrocarbons and PAH in Fish and Shellfish from Southwest Wales following the Sea Empress Oil Spill in 1996." *International Oil Spill Conference Proceedings*. no.1: 205-211.

Lewis, J.P., J.H. Tarnecki, S.B. Garner, D.D. Chagaris, and W.F. Patterson. 2020. Changes in Reef Fish Community Structure Following the Deepwater Horizon Oil Spill. *Scientific reports*, 10(1), 1-13.

Moreno, R., L. Jover, C. Diez, F. Sarda, and C. Sanpera. 2013. "Ten Years After the Prestige Oil Spill: Seabird Trophic Ecology as Indicator of Long-Term Effects on the Coastal Marine Ecosystem." *PLoS One*. 8(10): e77360.

Muller-Karger, F E., and R.A. Castro. 1994. Mesoscale Processes Affecting Phytoplankton Abundance in the Southern Caribbean Sea. *Continental Shelf Research*, 14(2-3), 199-221.

Murawski, S.A., J.P. Kilborn, A.C. Bejarano, and D.Chagaris. 2021. "A Synthesis of Deepwater Horizon Impacts on Coastal and Nearshore Living Marine Resources." *Frontiers in Marine Science*, Volume 7, February 1, 2021. Accessed: September 2021. Retrieved from: https://www.frontiersin.org/articles/10.3389/fmars.2020.594862/full

Neff, J. 2002. Bioaccumulation in Marine Organisms: Effect of Contamination from Oil Well Produced Water. Elsevier Inc. 468 pp.

NRC (National Research Council). 2003. Oil in the Sea iii. Inputs, Fates, and Effects. Washington, D.C.: National Academies Press.

Ozhan, K., M.L. Parsons, and S. Bargu. 2014. "How Were Phytoplankton Affected by the Deepwater Horizon Oil Spill?" *Bioscience*, 64(9).

Pascual, M., B. Rives, C. Schunter, and E. Macpherson. 2017. "Impact of Life History Traits on Gene Flow: A Multispecies Systematic Review across Oceanographic Barriers in the Mediterranean Sea." *PLoS ONE* 12, no.5: e0176419. https://doi.org/10.1371/journal.pone.0176419

Piatt, J.F., and P. Anderson. 1996. Response of Common Murres to the Exxon Valdez Oil Spill and Long-Term Changes in the Gulf of Alaska Marine Ecosystem. American Fisheries Society Symposium, 18: 720–737.

RPS. 2021. ExxonMobil Guyana Yellowtail Oil Spill Modeling Analysis, 21-P-214165: Oil Spill Risk Assessment.

Snyder, S.M., E.L. Pulster, D.L. Wetzel, and S.A. Murawski. 2015. PAH Exposure in Gulf of Mexico Demersal Fishes, Post-Deepwater Horizon. *Environmental Science & Technology*, 49(14), 8786-8795.

Tang, Danling, Jing Sun, Li Zhou, Sufen Wang, Ramesh P. Singh, and Gang Pan. 2019. Ecological Response of Phytoplankton to the Oil Spills in the Oceans. *Geomatics, Natural Hazards and Risk*. 10:1, 853-872, doi:10.1080/19475705.2018.15491

Tansel, B. 2014. Propagation of Impacts after Oil Spills at Sea: Categorization and Quantification of Local vs Regional and Immediate vs Delayed Impacts. *International Journal of Disaster Risk Reduction*, 7, 1-8.

Teal, J.M., and R.W. Howarth. 1984. “Oil Spill Studies: A Review of Ecological Effects.” *Environmental Management*, 8: 27. doi:10.1007/BF01867871.

Wang, L., B. Zheng, and W. Meng. 2008. “Photo-Induced Toxicity of Four Polycyclic Aromatic Hydrocarbons, Singly and in Combination, to the Marine Diatom Phaeodactylum Tricornutum.” *Ecotoxicology and Environmental Safety.* 71: 465–472.

Section 9.19 Waste Management Infrastructure Capacity

Damon, Neola. 2021. Cell Two of Haags Bosch Landfill officially opens. Department of Public Information, 20 March 2021. Accessed: August 2021. Retrieved from: Cell Two of Haags Bosch Landfill officially opens – Department of Public Information (dpi.gov.gy)

Section 9.20 Cultural Heritage

ERM/EMC (Environmental Resources Management and Environmental Management Consultants). 2018. Liza Phase 1 Enhanced Coastal Sensitivity Mapping – Ecosystem Services.

Section 9.23 Indigenous Peoples

ERM/EMC (Environmental Resources Management and Environmental Management Consultants). 2018. Liza Phase 1 Enhanced Coastal Sensitivity Mapping – Ecosystem Services.

Section 9.24 Transboundary Impacts

BirdLife International. 2019 Marine IBA e-Atlas. Accessed: August 2021. Retrieved from: https://maps.birdlife.org/marineibas/

BSEE (Bureau of Safety and Environmental Enforcement). 2016. Worst Case Discharge Analysis (Volume I, February 2016).

CBF (Caribbean Biodiveristy Fund). 2021. Grenada launches its newest Marine Protected Area: Grand Anse. Accessed: August 2021. Retrieved from: https://caribbeanbiodiversityfund.org/news/56-grenada-launches-its-newest-marine-protected-area-grand-anse

C-CAM (Caribbean Coastal Areas Management Foundation). 2013. Climate Change Risk Assessment Report: Portland Bight Protected Area. Accessed: August 2021. Retrieved from: http://parkscaribbean.net/wp-content/uploads/2013/11/Portland%20Bight%20Protected%20Area%20Climate%20Change%20Risk%20Assessment%20(2013).pdf

CaMPAM (Caribbean Marine Protected Area Management) Network and Forum. Undated. Fact Sheet: Arrefices de Suroeste MPA. Accessed: July 2021. Retrieved from: https://studylib.es/doc/6632796/arrecifes-del-suroeste

ERM (Environmental Resources Management). 2018a. Nearshore and Offshore Fisheries Study Summary Report 2017—2018. May 2018.

_____. 2018b. Remotely Operated Vehicle Imagery Analysis. Liza Phase 1 Development Project. May 2018.

FAO (Food and Agricultural Organization of the United Nations). 2018. Fishery and Aquaculture Country Profiles: The Republic of Trinidad and Tobago. Accessed: August 2021. Retrieved from: www.fao.org/fishery/facp/TTO/en

Finlay, J. 2012. Management Plan for Woburn Clarkes Court Bay Marine Protected Area. Accessed: August 2021. Retrieved from: https://parkscaribbean.net/wp-content/uploads/2013/11/Woburn%20Clarkes%20Court%20Bay%20MPA%20Management%20Plan%20(2012).pdf

Girot, Pascal O. 2019. Mid-Term Evaluation Report: Project “Conserving Biodiversity in Coastal Areas Threatened by Rapid Development of Tourism and Physical Infrastructure (00092146)", Dominican Republic. Prepared for the Ministry of Tourism, Ministry of Environment and Natural Resources. Accessed: August 2021. Retrieved from: https://erc.undp.org/evaluation/documents/download/15255

GMAFF (Grenada Ministry of Agriculture, Forestry and Fisheries). 2010. Molinière-Beauséjour Marine Protected Area Management Plan. Accessed: August 2021. Retrieved from: https://parkscaribbean.net/wp-content/uploads/2013/11/MBMPA-Management-Plan-(2010).pdf

Miloslavich, P., A. Martín, E. Klein, Y. Díaz, C.A. Lasso, J.J. Cárdenas, and O.M. Lasso-Alcalá. 2011. Biodiversity and Conservation of the Estuarine and Marine Ecosystems of the Venezuelan Orinoco Delta. In Ecosystems Biodiversity. O. Grillo and G. Venora (eds.). ISBN 978-953-307-417-7, 474 pp., Publisher: InTech, doi: 10.5772/913.

MOCPM. Undated. Marine Protected Areas (MPA). Accessed August 2021. Retrieved from: https://gov.gd/mocpm/marine-protected-areas-mpa.

NOAA (National Oceanic and Atmospheric Administration). 2015. Birds of a Feather Get Oiled Together. Office of Response and Restoration. Updated 4 May 2021. Accessed: August 2021. Retrieved from: https://response.restoration.noaa.gov/about/media/why-are-seabirds-so-vulnerable-oil-spills.html

UNESCO (United Nations Educational, Scientific and Cultural Organization). Undated. Parque Nacional Jaragua. Accessed: July 2021. Retrieved from: https://whc.unesco.org/en/tentativelists/6290/

_____. 2018. Parque Nacional Jaragua. Accessed: August 2021. Retrieved from: https://whc.unesco.org/en/tentativelists/6290/

_____. 2021. La Hotte Biosphere Reserve, Haiti. Accessed: August 2021. Retrieved from: https://en.unesco.org/biosphere/lac/lahotte

Wielgus, J., E. Cooper, R.Torres, and L. Burke. 2010. Coastal Capital: Dominican Republic. Case studies on the economic value of coastal ecosystems in the Dominican Republic. Working Paper. Washington DC:World Resources Institute. Accessed: August 2021. Retrieved from: https://files.wri.org/d8/s3fs-public/coastal_capital_dominican_republic_final.pdf

Chapter 10 Cumulative Impact Assessment

EPA (Guyana Environmental Protection Agency). 2021. Public Notices. 30 Days Public Notice – Demerara Harbour Bridge. Accessed: September 23, 2021. Retrieved from: https://www.epaguyana.org/epa/publicnotices2/summary/4-public-notices/758-30-days-public-notice-demerara-harbour-bridge

ERM (Environmental Resources Management). 2018. Enhanced Coastal Sensitivity Mapping—Biodiversity. Unpublished report to the Guyana EPA.

ERM/EMC (Environmental Resources Management and Environmental Management Consultants). 2018. Liza Phase 1 Enhanced Coastal Sensitivity Mapping – Ecosystem Services.

Government of Guyana. 2012. Guyana: Second National Communication to the UNFCCC. March 2012. Accessed: September 2021. Retrieved from: https://unfccc.int/resource/docs/natc/guync2.pdf

IFC (International Finance Corporation). 2012. Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts. 1 January 2012. Accessed: August 2021. Retrieved from: https://www.ifc.org/wps/wcm/connect/8804e6fb-bd51-4822-92cf-3dfd8221be28/PS1_English_2012.pdf?MOD=AJPERES&CVID=jiVQIfe

_____. 2013. Good Practice Handbook—Cumulative Impact Assessment and Management: Guidance for Private Sector in Emerging Markets. Accessed: August 2021. Retrieved from: https://www.ifc.org/wps/wcm/connect/58fb524c-3f82-462b-918f-0ca1af135334/IFC_GoodPracticeHandbook_CumulativeImpactAssessment.pdf?MOD=AJPERES&CVID=kbnYgI5

MacDonald, J., S. Harper, S. Booth, and D. Zeller. 2015. Guyana Fisheries Catches: 1950-2010. Working Paper Series; Working Paper #2015-21. Fisheries Centre, The University of British Columbia. Accessed: July 2021. Retrieved from: http://www.seaaroundus.org/doc/publications/wp/2015/MacDonald-et-al-Guyana.pdf

Ministry of Public Works. 2021. Project Summary: Replacement of the Existing Demerara Harbour Bridge. August 2021. Accessed: September 2021. Retrieved from: https://www.epaguyana.org/epa/project-summary2/summary/5-project-summary/759-replacement-demerara-harbour-bridge-project-summary

OilNOW. 2020. CGX Energy gets 1-year extension on deadline to drill Guyana well. 27 November 2020. Accessed: September 2021. Retrieved from: https://oilnow.gy/featured/cgx-energy-gets-1-year-extension-on-deadline-to-drill-guyana-well/

_____. 2021a. Multi-billion-dollar Vreed-en-Hoop port facility gets greenlight from EPA. 8 September 2021. Accessed: September 2021. Retrieved from: https://oilnow.gy/featured/multi-billion-dollar-vreed-en-hoop-port-facility-gets-greenlight-from-epa/

_____. 2021b. Repsol planning to drill another well offshore Guyana in 2022 – head of exploration. 20 August 2021. Accessed: September 2021. Retrieved from: https://oilnow.gy/featured/repsol-planning-to-drill-another-well-offshore-guyana-in-2022-head-of-exploration/

Stabroek News. 2021. Andron Alphonso seeking to set up shore base at Best Village. 26 July 2021. Accessed: September 2021. Retrieved from: https://www.stabroeknews.com/2021/07/26/news/guyana/andron-alphonso-seeking-to-set-up-shore-base-at-best-village/

Stiles, M.L., J. Stockbridge, M. Lande, and M.F. Hirshfield. 2010. Impacts of Bottom Trawling on Fisheries, Tourism, and the Marine Environment. OCEANA. May. Accessed: December 2021. Retrieved from: https://oceana.org/wp-content/uploads/sites/18/Trawling_BZ_10may10_toAudrey.pdf

Thomas, Marcelle. 2021. “TriStar gets approvals to start works for US$100+M Versailles shore base.” *Stabroek News*, 15 August 2021. Accessed: September 2021. Retrieved from: https://www.stabroeknews.com/2021/08/15/news/guyana/tristar-gets-approvals-to-starts-works-for-us100m-versailles-shore-base/

Tomic, Bartolomej. 2021. “Guyana: Tullow Oil, Partners Keep Control over Orinduik Offshore Block until 2023. *Offshore Engineer*, 15 March 2021. Accessed: September 2021. Retrieved from: https://www.oedigital.com/news/486004-guyana-tullow-oil-partners-keep-control-over-orinduik-offshore-block-until-2023

Tullow Oil. Undated. Tullow in Guyana. Accessed: September 2021. Retrieved from: https://www.tullowoil.com/our-operations/south-america/guyana/

UNISDR (United Nations International Strategy for Disaster Reduction). 2014. Prevention Web: Guyana Disaster & Risk Profile. Accessed: July 2021. Retrieved from: http://web.archive.org/web/20210525124623/https://www.preventionweb.net/countries/guy/data/

WHO (World Health Organization). Undated. Flooding and Communicable Diseases Fact Sheet. Accessed: September 2021. Retrieved from: https://www.who.int/hac/techguidance/ems/FloodingandCommunicableDiseasesfactsheet.pdf

World Bank. 2019. ThinkHazard Tool– Identify Natural Hazards in your Project Area and Understand how to Reduce their Impact. Accessed: July 2021. Retrieved from: http://thinkhazard.org/en/

Chapter 13 Recommendations

IMO (International Maritime Organization). 2004. International Convention for the Control and Management of Ships' Ballast Water. BWM/CONF/36. 16 February 2004. Accessed: July 2021. Retrieved from: http://library.arcticportal.org/1913/1/International%20Convention%20for%20the%20Control%20and%20Management%20of%20Ships%27%20Ballast%20Water%20and%20Sediments.pdf

JNCC (Joint Nature Conservation Committee). 2017. JNCC Guidelines for Minimising the Risk of Injury to Marine Mammals from Geophysical Surveys. Accessed: July 2021. Retrieved from: http://jncc.defra.gov.uk/pdf/jncc_guidelines_seismicsurvey_aug2017.pdf

Personal Communications

Environmental Management Consultants

EMC Personal Communication 1. Email from Ministry of Education with list of Nursery Schools in Guyana (Regions 1-6). 26 March 2018

EMC Personal Communication 2. Email from Ministry of Education with List of Secondary Schools in Guyana. 26 March 2018

EMC Personal Communication 3. Telephone conversation with Ministry of Education on number Primary Schools in Guyana (Regions 1-6). 26 March 2018

EMC Personal Communication 4. Email from Ministry of Agriculture on Fisheries Production 2018. 8 May 2019.

EMC Personal Communication 6. Email from the National Trust of Guyana. 9 May 2019

EMC Personal Communication 7. Interview with Jewanram Realty Personnel. 2 May 2019.

EMC Personal Communication 8. Email from Carol Comes. 14 May 2019.

EMC Personal Communication 9. Email from Reid's Realty. 19 May 2019.

EMC Personal Communication 10. Email from Kanuku Suites. 26 April 2019.

EMC Personal Communication 11. Email from Cara Lodge. 5 May 2019.

EMC Personal Communication 12. Email from Brandsville Hotel. 5 May 2019.

EMC Personal Communication 13. Email from El Dorado Inn. 5 May 2019.

EMC Personal Communication 14. Email from Regency Suites. 16 May 2019.

EMC Personal Communication 15. Email from Grand Coastal Hotel. 16 May 2019.

EMC Personal Communication 16. Email from Pegasus Hotel Guyana. 22 May 2019.

EMC Personal Communication 17. Interview with Eugene Corria International Airport. 25 June 2019.

EMC Personal Communication 18. Telephone Conversation with Roraima Duke Lodge. 2 July 2019.

Environmental Resources Management

ERM Personal Communication 1. Interview with the Guyana Rice Producers' Association. 6 September 2016.

ERM Personal Communication 2. Interview with the Guyana Association of Trawler Owners and Seafood Processors. 5 September 2016.

ERM Personal Communication 3. Interview with the Department of Tourism. 30 August 2016.

ERM Personal Communication 4. Interview with Mainstay/Whyaka Amerindian Village. 2 September 2016.

ERM Personal Communication 5. Interview with Pomeroon Women's Agro-Processors Association. 31 August 2016.

ERM Personal Communication 6. Interview with Supenaam-Parika Speedboat Operators Association. 31 August 2016.

ERM Personal Communication 7. Interview with Ministry of Public Health. 29 August 2016.

ERM Personal Communication 8. Interview with Ministry of Communities. 29 August 2016.

ERM Personal Communication 9. Interview with Ministry of Public Infrastructure. 2 September 2016.

ERM Personal Communication 10. Interview with Private Sector Commission of Guyana. 2 September 2016.

ERM Personal Communication 11. Interview with Guyana Hindu Dharmic Sabha. 2 September 2016.

ERM Personal Communication 12. Interview with Ministry of Agriculture. 5 September 2016.

ERM Personal Communication 13. Interview with West End Agricultural Development Society. 2 September 2016.

ERM Personal Communication 14. Interview with fisherfolk in Lima. 31 August 2016.

ERM Personal Communication 15. Interview with anonymous fisherfolk in Charity. 31 August 2016.

ERM Personal Communication 16. Interview with National Aquaculture Association. 6 September 2016.

ERM Personal Communication 17. Interview with Vilvordeen/Fairfield Women's Association. 31 August 2016.

ERM Personal Communication 18. Interview with Member of Lima Fisherman's Development Co-operative. 31 August 2016.

ERM Personal Communication 19. Interview with Fish Processor in Lima Area. 31 August 2016.

ERM Personal Communication 20. Interview with RDC 2 Chairman. 16 April 2018.

ERM Personal Communication 21. Email from Ministry of Agriculture. 13 September 2021.

ERM Personal Communication 22. Scoping meeting with members of the Ministry of Agriculture Fisheries Department, Fishing Industry, Trawlers Association, Noble House Seafoods, Global Seafood, and Artisanal Fishing Association, 19 April 2018.

ERM Personal Communication 23. Christopher Lynch, Petroleum Division, GGMC 20 April 2018.

ERM Personal Communication 24. Interview with former Fisheries Department Director and liaison for fishing community, 1 May 2018.

ERM Personal Communication 25. Interview with Leon Moore, 2018.

ERM Personal Communication 26. Interview with Romeo De Freitas, 2018.

ERM Personal Communication 27. Interview with MARAD Representatives. 19 April 2018.

ERM Personal Communication 28. Meeting Summary, Parika NDC, 9 September 2021.

ERM Personal Communication 29. Interview with Captain of Imbotero Village Region 1, September 2021.

ERM Personal Communication 30. Meeting with the National Trust National Trust of Guyana, 5 November 2021.

ERM Personal Communication 31. Engagement with Region 1 Communities. 2021.

ERM Personal Communication 32. Telephone interview with Arnold Benjamine, Chairman of Almond Beach CDC, 20 September 2021.

ERM Personal Communication 33. Interview with Region 5 Regional Democratic Council. 14 September 2021.

ERM Personal Communication 34. Interview with No. 52 and No. 74 Villages NDC. 27 September 2021.

ERM Personal Communication 35. Interview with Mon Repos / La Reconnaisance NDC. 3 September 2021.

Environmental Resources Management/ Environmental Management Consultants

ERM/EMC Personal Communication 1. Meeting with National Trust of Guyana, 18 May 2018.

ERM/EMC Personal Communication 2. Interview with National Trust, April 26, 2019.

ERM/EMC Personal Communication 3. Interview with Department of Tourism, April 30, 2019.

ERM/EMC Personal Communication 4. Interview with Department of Fisheries, May 2, 2019.

ERM/EMC Personal Communication 5. Interview with NAREI, May 3, 2019.

ERM/EMC Personal Communication 6. Interview with Ministry of Communities, May 7, 2019.

ERM/EMC Personal Communication 7. Interview with Ministry of Agriculture, May 7, 2019.

ERM/EMC Personal Communication 8. Interview with Guyana Lands and Surveys Commission, May 10, 2019.

ERM/EMC Personal Communication 9. Interview with Bureau of Statistics, May 16, 2019.

Esso Exploration and Production Guyana Limited

EEPGL Personal Communication 1. Interview with Hotel Managers. 2016

ExxonMobil

ExxonMobil Personal Communication 1. Email from Captain Jaeson Coelho, Nautical Advisor—Marine Systems & Operations, Offshore and Infrastructure, Upstream Engineering CSC regarding shipping lane description and shipping lane management. 15 November 2016.