Environmental Impact Assessment (EIA) Report for the Liquefied Natural Gas Project in Cabo Delgado

FINAL EIA REPORT- VOLUME II

Project ref: 0133576

February 2014

Anadarko Moçambique Área 1, Lda

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IMPACTO PROJECTOS E ESTUDOS AMBIENTAIS

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Volume II – Impact Assessment, Management, Implementation and Conclusions

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Chapter 10

Introduction to Impact Assessment and Mitigation

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10 INTRODUCTION TO IMPACT ASSESSMENT AND MITIGATION

10.1 INTRODUCTION

This chapter provides an overview of the approach used for assessing impacts and determining mitigation. The impact assessment comprised the following main activities:

- analysis of baseline data and identification of baseline sensitivities;
- consideration of stakeholder concerns raised during the EPDA (scoping) Phase;
- identification of potential significant impacts;
- development and refinement of mitigation measures (mitigation workshops and meetings were held with the Project's Engineering Team and contractors to ensure the proposed mitigation measures were practical and implementable);
- revision of the Project layout, based on baseline sensitivities and inputs from environmental and social specialists; and
- evaluation of the significance of residual (post-mitigation) impacts. A wide range of different measures to mitigate impacts have been identified in the EIA Report and the Project is committed to their implementation, success and continuous improvement (see *Chapter 17*).

10.2 PREDICTION AND EVALUATION OF IMPACTS

Chapters 11 to *15* identify and assess the potential impacts and risks associated with Project activities during the construction and operation phases. A screening process was conducted by specialists to identify those impacts that were not considered to be significant and which did not warrant further assessment. The impacts assessed in the following chapters were those deemed to be important for decision making.

These impacts were assessed in accordance with the methodology and assessment criteria detailed in *Chapter 3* and summarised below.

10.2.1 Impact Prediction

There are a number of ways that impacts may be described and quantified. An impact is essentially any change to a resource or receptor brought about by the presence of the Project component or by the execution of a Project-related

activity. There are a number of ways that impacts may be described and quantified, including:

- nature of impact: positive or negative;
- type of impact: direct, indirect or cumulative;
- duration of impact: temporary, short term, medium term, long term or permanent; and
- scale of impact: onsite, local, regional, national or international/ transboundary.

The types of impacts and terminology used in the assessment are outlined in *Table 10.1*.

Table 10.1 Defining the Nature of the Impact

Term	Definition
Nature of Impact	
Positive	An impact that is considered to represent an improvement on the baseline or introduces a positive change.
Negative	An impact that is considered to represent an adverse change from the baseline, or introduces a new undesirable factor.
Type of Impact	
Direct impact	Impacts that result from a direct interaction between a planned project activity and the receiving environment/receptors (eg between occupation of a site and the pre-existing habitats, or between an effluent discharge and receiving water quality).
Indirect impact	Impacts that result from other activities that are encouraged to happen as a consequence of the Project (eg in-migration for employment placing a demand on resources). Indirect impacts can also be referred to as induced or secondary impacts.
Cumulative impact	Impacts that act together with other impacts (including those from concurrent or planned future third party activities) to affect the same resources and/or receptors as the Project.

This EIA considers routine and non-routine events that may lead to potential impacts. Non-routine events generally relate to accidents or unplanned events (such as oil/fuel spills, emergency flaring or venting of gas, etc) that may result in adverse impacts. In these cases, the probability of the event occurring needs to be considered.

10.2.2 Assessing Significance

For the purposes of this EIA, the following definition has been adopted: *'An impact is significant if, in isolation or in combination with other impacts, it should be taken into account in the decision-making process.'*

It is generally accepted that significance is a function of the magnitude of the impact and the likelihood of the impact occurring. It is widely accepted that

impact magnitude (or severity) is a function of the extent, duration and intensity of the impact.

The criteria used to determine significance are summarised in *Table 10.2* (1). The prediction takes account of mitigation measures that are already an integral part of design.

Table 10.2 Significance Criteria

Impact Magnitude – the Degree of Change Brought About in the Environment	
Extent	**Onsite:** impacts that are limited to the direct area of disturbance and immediate surrounds. **Local:** impacts that affect an area in a radius of up to 10km around the site. **Regional:** impacts that affect regionally important environmental resources or are experienced at a regional scale, as determined by administrative boundaries or habitat type/ecosystem. **National:** impacts that affect nationally important environmental resources, or affect an area that is nationally important, or that have macro-economic consequences. **Transboundary/international:** impacts that affect internationally important resources, such as areas protected by international conventions.
Duration	**Temporary:** impacts are predicted to be of short duration and intermittent/occasional (typically less than one year). **Short term:** impacts that are predicted to last between one and five years. **Medium term:** impacts that are predicted to last between five and 10 years. **Long term:** impacts that will last longer than 10 years and cease when the Project stops operating. **Permanent:** impacts that cause a permanent change in the affected receptor or resource (eg removal or destruction of ecological habitat) that endures substantially beyond the Project lifetime.
Intensity(2)	BIOPHYSICAL ENVIRONMENT: *Intensity can be considered in terms of the sensitivity of the biodiversity receptor (ie habitats, species or communities).* **Negligible:** the impact on the environment is not detectable. **Low:** the impact affects the environment in such a way that natural functions and processes are not materially affected. **Medium:** where the affected environment is altered but natural functions and processes continue, albeit in a modified way. **High:** where natural functions or processes are altered to the extent that they will temporarily or permanently cease. ***Where appropriate, national and/or international standards are to be used as a measure intensity of the impact.*** SOCIO-ECONOMIC ENVIRONMENT: *Intensity can be considered in terms of the ability of project-affected people/communities to adapt to changes brought about by the project.*

(1) In some cases, specialists have slightly modified the means of assessing significance based on what is most appropriate to their subject matter. Where this is the case, it has been clearly outlined.
(2) The frequency of the activity causing the impact also has a bearing on the intensity of the impact, ie the more frequent the activity, the higher the intensity.

Impact Magnitude – the Degree of Change Brought About in the Environment	
	Negligible: there is no perceptible change to people's livelihoods. **Low:** people/communities are able to adapt with relative ease and maintain pre-impact livelihoods. **Medium:** people/communities are able to adapt with some difficulty and maintain pre-impact livelihoods, but only with a degree of support. **High:** affected people/communities will not be able to adapt to changes and continue to maintain pre-impact livelihoods.
Impact Likelihood – the Likelihood that an Impact will Occur	
Unlikely	The impact is unlikely, but may occur at some time during normal operating conditions.
Likely	The impact is likely to occur at some time during normal operating conditions.
Definite	The impact will occur at some time during normal operating conditions.

Once a rating was determined for magnitude and likelihood, the risk matrix in *Table 10.3* was used to determine the impact significance for positive or negative impacts.

Table 10.3 Impact Significance

SIGNIFICANCE RATING				
	LIKELIHOOD	Unlikely	Likely	Definite
MAGNI-TUDE	Negligible	Negligible	Negligible	Negligible
	Low	Negligible	Minor	Minor
	Medium	Minor	Moderate	Moderate
	High	Moderate	Major	Major

Table 10.4 outlines the various definitions for significance of an impact and is based on the significance rating matrix.

Table 10.4 Significance Definitions

Significance Definitions	
Negligible significance	An impact of negligible significance is where a resource or receptor will not be affected in any way by a particular activity, or the predicted effect is deemed to be imperceptible or is indistinguishable from natural background levels.
Minor significance	An impact of minor significance is one where an effect will be experienced, but the impact magnitude is sufficiently small and well within accepted standards, and/or the receptor is of Low sensitivity/value/vulnerability/importance.
Moderate significance	An impact of moderate significance is one within accepted limits and standards. The emphasis for moderate impacts is on demonstrating that the impact has been reduced to a level that is ALARP. This does not necessarily mean that moderate impacts have to be reduced to minor impacts, but that moderate impacts are being managed effectively and efficiently.

Significance Definitions	
Major significance	An impact of major significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resources/receptors. A goal of the EIA process is to get to a position where the Project does not have any major residual impacts, certainly not ones that would endure into the long term or extend over a large area. However, for some aspects, there may be major residual impacts after all practicable mitigation options have been exhausted (ie ALARP has been applied). An example might be the visual impact of a development. It is then the function of regulators and stakeholders to weigh such negative factors against the positive factors, such as employment, in coming to a decision on the Project.

Once the significance of the impact has been determined, it is important to qualify the degree of confidence in the assessment. Confidence in the prediction is associated with any uncertainties, for example, where information is insufficient to assess the impact. Degree of confidence can be expressed as Low, Medium or High.

10.2.3 Structure of Impact Assessment Chapters

Discussion of impacts is divided into offshore environmental, onshore environmental and socio-economic categories (*Chapters 11, 12* and *13* respectively), as outlined in *Table 10.5*.

The offshore impact assessment chapter (*Chapter 11)* addresses the deep offshore and near shore (within Palma Bay) marine impacts. The onshore impact assessment chapter (*Chapter 12)* discusses impacts on the terrestrial environment. The socio-economic chapter (*Chapter 13*) considers impacts to the socio-economic receptors, both onshore (eg communities) and offshore (eg shipping and navigation).

Unplanned events arising from non- routine Project activities are assessed separately in *Chapter 14*. Cumulative impacts are assessed in *Chapter 15*.

Table 10.5 Structure of the Impact Assessment Chapters

Chapter	Receptor/ Resource
Chapter 11 – Offshore and Near Shore Environmental Impact Assessment	
	Offshore marine ecology
	Near Shore marine ecology
Chapter 12 – Onshore Environmental Impact Assessment	
	Air quality
	GHG Emissions/ Climate change
	Noise
	Landscape, seascape and visual
	Waste
	Soils
	Hydrology
	Groundwater
	Surface water ecology
	Vegetation

Chapter	Receptor/ Resource
	Herpetofauna Avifauna Mammals
Chapter 13 – Socio-economic Impact Assessment	
	Social (Physical and economic displacement, tourism, PIIM, economy) Community health Shipping and navigation Archaeology
Chapter 14 –Unplanned, Non-routine Events	
	All relevant environmental and socio-economic resources/receptors
Chapter 15 – Cumulative Impacts	
	All relevant environmental and socio-economic resources/receptors

The assessment of impacts on a resource/receptor resulting from a Project activity is described in a systematic manner under three subheadings.

- **Impact assessment**: the Project activities that give rise to potential impacts are identified and the magnitude, likelihood and significance of the impacts on the receptor or resource assessed without the implementation of mitigation or enhancement measures.

- **Mitigation measures**: the key mitigation or enhancement measures that the Project has agreed to are defined here. These measures described how negative impacts can be avoided, minimised, remedied or compensated and how positive impacts can be enhanced.

- **Residual impacts:** an assessment of the significance of the impacts following the implementation of the recommended mitigation or enhancement measures is provided here.

The assessment exercise was supported by technical studies (eg to quantify noise and air quality impacts through modelling). Where relevant, standards or guidelines are used to determine the acceptability of impacts and gaps in knowledge are made clear. A wide range of different measures to mitigate impacts have been identified in the EIA Report and the Project is committed to their implementation, success and continuous improvement (see *Chapter 17*).

10.3 INTEGRATION AND MITIGATION WORKSHOPS

Mitigation measures recommended by the EIA Team (including the various environmental and socio-economic specialists) were agreed with the Project, and residual impacts were determined based on the assumption that these agreed mitigation measures will be implemented by the Project or the Project's

contractors. Mitigation measures (in particular, measures that resulted in a change to the design layout of the Project) were developed and verified as feasible through a series of mitigation workshops involving key personnel from the EIA Team, AMA1 and potential FEED Contractors. In addition, several meetings were held between the Engineering Team and some specialists to refine and finalise mitigation measures, including the incorporation of avoidance wherever possible in the Project design.

The objectives of each of the workshops and ad hoc meetings, as well as a list of attendees (by team), are presented in *Table 10.6*.

The three workshops took place over an eight-month period, starting from the time that specialist baseline findings became available, through various updates and changes to the Project description, and lasting through the completion of the specialist reports. The workshops focused on two main areas:

- mitigation, management and monitoring measures proposed by the EIA Team, and agreement of these with AMA1; and
- discussion of certain key issues and how the Project planned to deal with these, such as:
    - ecologically sensitive areas within Afungi Project Site and the technical feasibility of revising the Onshore Project Footprint Area to avoid sensitive areas;
    - possible techniques for bringing the pipelines from offshore, through Palma Bay to the Afungi Project Site to avoid or minimise impacts to sensitive and important marine biotopes (eg coral and seagrass);
    - options for the disposal of dredge material;
    - waste management practices; and
    - exclusion zones in the near shore to minimise impacts to transportation routes along the coast.

Table 10.6 Integration and Mitigation Workshops/Meetings

Dates	Objectives of Workshop or Meeting	Attendees (Representatives from)
Integration Workshop: 25–26 January 2012	• Facilitate integration between specialists. • Obtain a thorough understanding of the base case Project description through direct interaction with the Engineering Team. • Obtain a better understanding of the affected environment (baseline) and key sensitivities across all specialist studies.	• ERM and Impacto EIA Project Management Team • Environment and social specialists involved in the EIA • Project Engineering Team (Offshore and Onshore) • INP representative

Dates	Objectives of Workshop or Meeting	Attendees (Representatives from)
Integration and Mitigation Workshop: 12–13 July 2012	• Understand specialist findings/ recommendations; in particular, key impacts, proposed mitigation, monitoring and management measures. • Align/integrate specialists. • Workshop mitigation, monitoring and management measures with all present.	• ERM and Impacto EIA Project Management Team • Environment and social specialists involved in the EIA • Project Engineering Team (Offshore and Onshore)
Mitigation Workshop: 28–29 August 2012	• Discuss and agree on possible mitigation measures with FEED Contractors and AMA1 to allow EIA Team to finalise the impact assessment chapters and Environmental Management Plan (EMP).	• ERM and Impacto EIA Project Management Team • Key environment and social specialists involved in the EIA • Project Engineering Team (Offshore and Onshore) • Onshore FEED Contractors • Near Shore infrastructure design engineers
Ad hoc meetings: June 2012 to September 2012	• Discuss and agree on proposed mitigation measures.	• Environment and social specialists involved in the EIA • Project Engineering Team

The outcomes of the workshops provided the basis for both the mitigation measures described in the following chapters and the Environmental and Social Management Plan (ESMP) in *Annex D*. These workshops also influenced the Project design iteratively, with the feedback from the EIA specialists incorporated into the Project layout and design in real time (described in *Section 10.4* below).

The integration and mitigation workshops facilitated a robust assessment of impacts and challenging of the feasibility of the proposed mitigation measures. The mitigation measures (or their performance-based objectives) have been agreed to and are an integral part of the Project. The implementation of mitigation measures will be incorporated into the FEED/EPC Contractors' contract requirements, along with proposed monitoring and reporting.

10.4 REVISIONS TO THE PROJECT LAYOUT

The development of appropriate mitigation measures is a key component of the EIA process. *Chapters 11* to *13* provide detail on the identified impacts and range of mitigation measures. In light of the potential impacts, the EIA Team worked with the Project's Engineering Team to revise the Project layout to avoid and/or minimise a range of potential impacts on the biophysical and socio-economic environment. In light of the ecological value and sensitivity of the region (see *Chapters 6* to *8*), avoiding or minimising impacts through appropriate mitigation is an important consideration. The proposed mitigation through revising/reducing the layout of components of the Project

is described here to provide a better understanding of the proposed post-mitigation Project description.

10.4.1 Revisions to the Offshore Project Description

Changes to the Pipeline Corridor between Rongui and Tecomaji

The proposed pipeline corridor was initially planned to transition from deep to shallow water and pass through the mid-point between the islands of Rongui and Tecomaji. However, the baseline surveys conducted in this area indicated that the proposed pipeline corridor would pass through an area of shallow fringing reefs. In review of the environmental sensitivities, the EIA Team identified a potential alternate route to the south between the islands, closer to Rongui Island, to avoid or minimise damage or disturbance to the fringing reefs. In discussion with the Project's Engineering Team, this alternate route, closer to Rongui Island, was agreed upon. This southern route is depicted in *Figure 10.1*.

The installation technique or method proposed for the pipeline in this area also presented the possibility of significant environmental impacts. A cutter suction dredger was initially proposed to dredge the channel between the islands of Rongui and Tecomaji. This method would use a rotating cutter head to loosen the carbonaceous rock and grind the material. The environmental concern associated with this was related to the likelihood of creating a large plume of finely ground calcium carbonate, which could potentially result in adverse impacts to the marine ecology within the bay and surrounds. The EIA Team proposed an alternate method that involves fracturing the carbonaceous rock through the use of small controlled underwater explosions to loosen the substrate, and then mechanically excavating the corridor. The Project's Engineering Team agreed that this was a viable option, and will task the dredging contractor with using this method (or similar) instead of dredging. The excavated material may provide beneficial use for armouring the pipeline, while providing a suitable medium to facilitate the recolonisation of coral.

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10°30'0"S 10°40'0"S 10°50'0"S 11°0'0"S 11°10'0"S 11°20'0"S

TANZANIA

Golfinho

Prosperidade

Mamba

Quionga
Assame
Calomba
Quiwia
Cabo Delgado Peninsula
Issa
Palma Bay
Tecomaji Island
Palma
Manguna
Nkalanga
Macala
Quitupo
Afungi Peninsula
Senga
Nkumbi
Maganja
Aienda
Matapata
Rongui Island
Queramimbi Island
Bawala
Olumbe
Vamizi Island
Metundo Island

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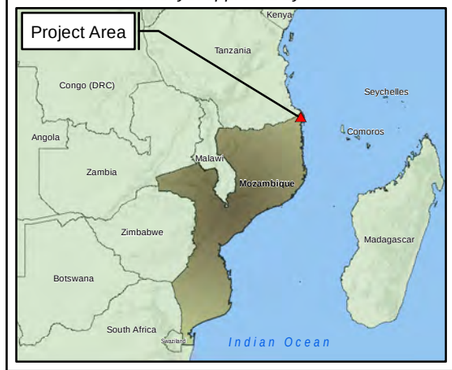
Legend

- Villages / Settlements
- Regional Roads
- Proposed Pipeline Corridor Route
- Cais
- Onshore Layout
- Afungi Project Site
- Prosperidade Gas Field
- Golfinho Gas Field *
- Mamba Gas Field

** Indicative area not yet approved by INP*



MAIN MAP SCALE:

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Figure 10.1: Locality of Pipeline Corridor

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: KG	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 400 000

DRAWING: Locality_of_Pipeline_corridor.mxd

REV: A

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Projection: UTM Zone 37 S. Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation AMA1, 2012. Inset Map: Esri Data & Maps

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Changes to the Pipeline Corridor within Palma Bay

It was initially proposed to dredge a channel, approximately 300m wide by 5m deep, within Palma Bay to accommodate access by the pipeline installation barge. The dredging of this channel is expected to result in the accumulation of approximately 6.6 million m^3 of dredge material. The environmental impacts associated with this method include the loss of biotopes within the footprint area of the dredge channel, as well as potential increases in turbidity.

The Project is discussing alternative installation methods with FEED Contractors to reduce the likely impacts associated with dredging and backfilling a pipeline corridor within Palma Bay. Considerations include mechanical (rather than dredger) methods to trench the pipe (eg use of a crawler in shallow water, and use of special pipeline trenching barges). The intent of these alternate methodologies is to reduce adverse impact to the coral and seagrass communities. This will be achieved by significantly reducing the expected volume of 6.6 million m^3 of dredge material and minimising the footprint area of the pipeline from an approximately 300m wide corridor to approximately 100m wide.

10.4.2 Revisions to the Onshore Project Layout

Field studies conducted during the Baseline Phase of the EIA identified and mapped sensitive habitats for a variety of vegetation, terrestrial fauna and avian species. Once these species-specific sensitive habitat maps were overlaid (see *Figure 10.2*), it became apparent that certain areas within the Afungi Project Site were more sensitive than others and contributed to the biodiversity of the Study Area. It was determined that most of the species relied heavily on the wetlands within the Onshore Project Footprint Area for the ecological functions they provide (food, water, breeding habitat, etc).

665000 670000 675000

8810000 8805000 8800000

Palma Bay

PROCESS/ UTILITIES AREA

TRAINS 1 & 2

TRAINS 3, 4, 5 & 6

CONSTRUCTION LAYDOWN/ STAGING AREA

OPERATIONS HOUSING AREA

Quitupo

CONSTRUCTION SUPPORT FACILITY AREA

PIPELINE INLET GAS AREA

AIR STRIP PASSENGER TERMINAL

AIR STRIP

OPERATIONS SUPPORT AREA

Maganja

bing

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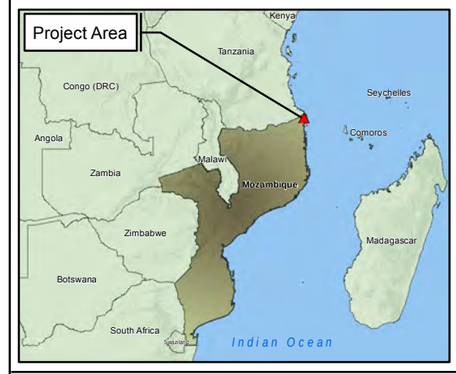
Legend

- Villages / Settlements
- Regional Roads
- Local Roads
- Nearshore Components
- Onshore Layout
- Airstrip
- Afungi Project Site

Sensitivity Rating

- Very High
- High
- Medium-High
- Med
- Low
- 150m Buffer



MAIN MAP SCALE:

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Figure 10.2:
"Base-Case" Onshore Project Footprint Area Overlaid on Sensitive Areas

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DATE: Oct 2013	CHECKED: AS	PROJECT: 0133576
DRAWN: AB	APPROVED: JR	SCALE: 1 : 50 000

DRAWING: Onshore Project Footprint Area Overlaid on Sensitive Areas.mxd

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Projection: UTM Zone 37 S, Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
ERM, 2012. Inset Map: Esri Data & Maps

SIZE: A3

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Once potential mitigation measures were compiled, it became obvious the Project could reduce adverse environmental impacts by revising the Onshore Project Footprint Area. With the above sensitivity map in mind, the Project began to investigate methods to avoid or minimise potential footprint impacts. This was facilitated by a series of interactions held between the EIA and Project Engineering Teams. The EIA Team, in conjunction with AMA1, revised the base case Project layout (*Figure 10.2*) to avoid or minimise impacts on the identified high-sensitivity areas (illustrated in *Figure 10.3*). The potential FEED Contractors were then tasked with determining whether they could design the Project to work within the revised areas. Those Contractors confirmed that they were able to work within the revised layout.

This mitigation exercise enabled the avoidance of some impacts and the minimisation of others to ALARP. The Revised Project Footprint Area effectively reduces the disturbance of areas of High to Very High terrestrial ecological sensitivity from approximately 2,340ha to 1,695ha, thereby avoiding approximately 645ha. *Table 10.7* below provides an overview of the reduced area of disturbance to terrestrial areas with a sensitivity rating of Medium and greater.

Table 10.7 Approximate Reduction in Disturbance to Sensitive Areas (Figure 10.3)

Sensitive Habitat Rating	Vegetation	Herpetofauna	Avian	Mammal
Medium	-2,698ha	-1,098ha	-2,697ha	-1,099ha
Medium–High	N/A	N/A	-112ha	N/A
High	+85ha	-51ha	-103ha	-6ha
Very High	-210ha	-323ha	N/A	N/A
Total reduction in disturbance	**-2,823ha**	**-1,472ha**	**-2,912ha**	**-1,105ha**

Note:
NA indicates that this habitat rating was not observed within the Survey Area.

In addition to the above described reductions, wetlands by their nature are considered to be sensitive ecosystems. The Revised Project Footprint Area reduces the area of disturbance to wetlands and their buffer areas from approximately 2,590ha to approximately 1,643ha, thereby avoiding 947ha in total.

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8810000

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Palma Bay

Quitupo

Maganja

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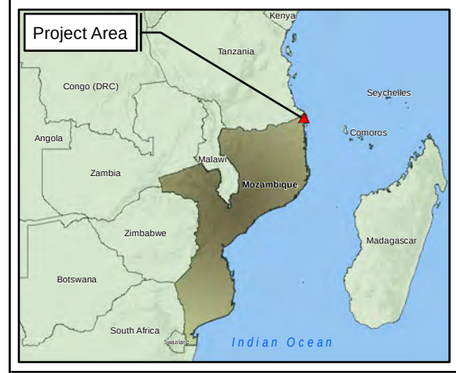
Legend

- Villages / Settlements
- Regional Roads
- Existing Roads
- Nearshore Components
- Airstrip
- Afungi Project Site
- Revised Project Footprint

Sensitivity Rating

- Very High
- High
- Medium-High
- Med
- Low
- 150m Buffer



MAIN MAP SCALE:

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Figure 10.3: Revised Onshore Project Footprint Area Overlaid on Sensitive Areas

CLIENT:

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DATE: Oct 2013	CHECKED: AS	PROJECT: 0133576
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DRAWING: Revised Onshore Project Footprint Area Overlaid on Sensitive Areas.mxd

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Impacto Projectos e Estudos Ambientais

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Projection: UTM Zone 37 S, Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
ERM, 2012. Inset Map: Esri Data & Maps

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Chapter 11

Offshore and Near Shore Environmental Impact Assessment and Mitigation

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11 OFFSHORE AND NEAR SHORE ENVIRONMENTAL IMPACT ASSESSMENT AND MITIGATION

11.1 INTRODUCTION

This chapter describes the potential Project-induced ecological impacts on the Offshore and Near Shore baseline marine environments resulting from the Project, as well as Project-induced changes to physical processes and water quality.

11.2 STRUCTURE OF CHAPTER

This chapter is structured as follows.

- *Section 11.3* describes the approach and methodology pertinent to the Near Shore and Offshore impact assessment.
- *Sections 11.4* to *11.8* consider Project activities that may potentially impact water quality, the seabed and marine ecology in the Offshore environment.
- *Sections 11.9* to *11.14* address the potential impacts associated with dredging activities, including disposal of dredge material in the Near Shore environment. These include the potential for increased turbidity, the remobilisation of heavy metals and organic compounds, physical disturbance and sediment deposition.
- *Sections 11.15* to *11.23* consider Project activities that potentially impact marine ecology in the Near Shore environment.

11.3 APPROACH AND METHODOLOGY

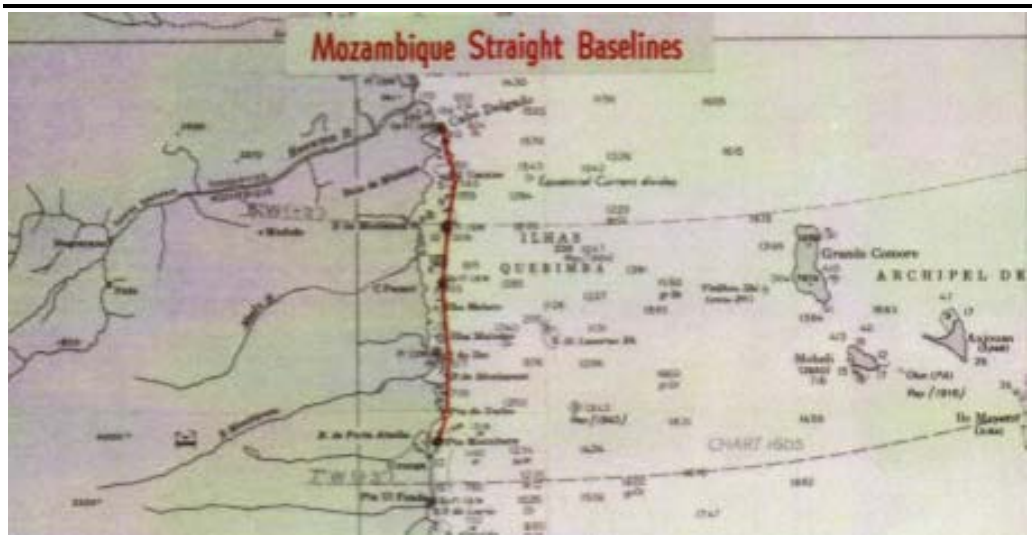
The impact assessment methodology used is explained in *Chapter 3* of this EIA Report. However, definitions of impact extent have been refined further to be more pertinent to the Near Shore and Offshore impact assessment. *Table 11.1* provides the definitions specific to this chapter.

In accordance with the UN Law of the Sea Convention (UNCLOS) (1982), Internal Waters are defined as waters landward of the Baseline, which delineates the inner (landward) limits of the territorial sea. Other Maritime Zones are measured from this Baseline. A straight baseline (1) is used in

(1) A normal baseline is the low-water line along the coast, as shown on large-scale charts officially recognised by the coastal states. Straight baselines may be used where the coastline is deeply indented (bays, ports and similar enclosed areas of the sea) or if there is a fringe of islands along the coast in its immediate vicinity.

Mozambique's northern coast, which incorporates Palma Bay, extending from Cabo Delgado Peninsula in the north for 110 nautical miles along the Quirimbas Archipelago to Cabo Conducia just south of Nacala, as shown in *Figure 11.1* (1). Accordingly, Palma Bay and associated islands are within Internal Waters, where Mozambique has full sovereign powers to control all activities as if they occurred on land (2). This is set out in The Sea Act (Law No. 4/1996, January 4).

Figure 11.1 Straight Baseline in Northern Mozambique



Key:
Red line shows the straight baseline from Cabo Delgado Peninsula in north to Cabo Conducia.

Source: US Department of State, International Boundary Study, Limits in the Seas, 1970.

For the purposes of this assessment, Offshore has been defined as the area beyond (or to the east of) Mozambique's Maritime Baseline. Near Shore refers to waters westward of the Maritime Baseline.

Table 11.1 provides the definitions of impact extent pertinent to the Offshore and Near Shore marine environment impact assessment. *Figure 11.2* indicates the approximate alignment of the Maritime Baseline, about 1.5km east of the islands of Rongui, Tecomaji, Queramimbi and Vamizi.

(1) First established in 1967 under Portuguese law (Jamine, 2007), and subsequently acknowledged in a United Nations Law of the Sea delimitation agreement between Mozambique and Tanzania on 28 December 1988.
(2) These powers, including powers over pollution prevention from shipping, may be stronger than in its Territorial or other waters. Territorial Sea is an area of sea up to a limit not exceeding 12 nautical miles, measured from baselines determined in accordance with this Law of the Sea Convention.

Table 11.1 Definition of Impact Extent Used for Near Shore and Offshore Marine Environment (Refer to Figure 11.2)

	Near Shore	**Offshore ***
Onsite	A 28km² block around the Near Shore Project infrastructure, as shown in *Figure 11.2*	An area of <5km² around source of Project activity
Local	The Internal Waters of Palma Bay inside the Maritime Baseline, as shown in *Figure 11.2*	5-50km² (~7x7km) from source of Project activity
Regional	The Internal Waters of Cabo Delgado Province inside the Maritime Baseline, as shown in *Figure 11.2*	An area of 50-500km² (~22x22km) around source of Project activity
National	Mozambique's Economic Exclusion Zone (EEZ), but beyond the Maritime Baseline of Cabo Delgado Province	Within Mozambique's EEZ
International	Outside of Mozambican EEZ (eg in Tanzanian or Comoros waters)	Outside of Mozambique's EEZ

Key:
* The extent defined for Offshore impacts is related to the location of Project activities (eg drilling).

The definitions used to describe impact extent in the Near Shore marine environment are illustrated in *Figure 11.3*.

Potential impacts to marine ecology resulting from the construction and operational phases are dealt with in this chapter, where applicable. The key Project activities likely to result in impacts to the Offshore Environment will take place in the vicinity of Golfinho and Prosperidade gas fields, in Area 1, and Mamba Gas Field in Area 4, as well as in Palma Bay.

40°20'0"E 40°30'0"E 40°40'0"E 40°50'0"E

10°40'0"S 10°50'0"S 11°0'0"S 11°10'0"S

Cabo Delgado Peninsula

Palma Bay

OFFSHORE

NEAR SHORE

Tecomaji Island

Afungi Peninsula

Rongui Island

OFFSHORE

Queramimbi Island

NEAR SHORE

Vamizi Island

OFFSHORE

NEAR SHORE

Metundo Island

bing

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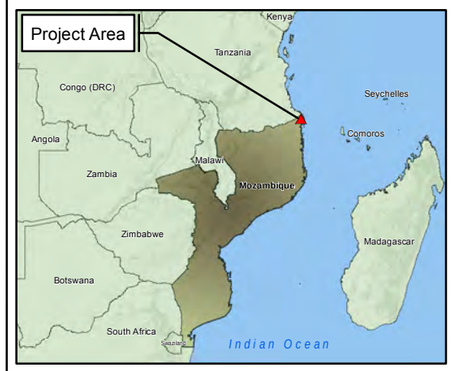
Legend

- Regional Roads
- Jetty
- Onshore Layout
- Afungi Project Site
- Mozambique's Maritime Baseline



MAIN MAP SCALE:

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Kilometers

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Figure 11.2:
Mozambique's Maritime Baseline

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: KG	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 230 000

DRAWING: Impact Extent Definitions Applied for the Near Shore.mxd

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Impacto Projectos e Estudos Ambientais

ERM

Projection: UTM Zone 37 S, Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation
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10°40'0"S 10°50'0"S 11°0'0"S 11°10'0"S

Cabo Delgado Peninsula

LOCAL

Palma Bay

ONSITE

Tecomaji Island

Afungi Peninsula

Rongui Island

Queramimbi Island

NATIONAL

REGIONAL

Vamizi Island

Metundo Island

bing

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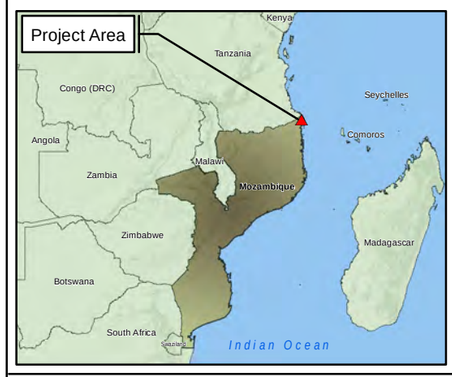
Legend

- Regional Roads
- Jetty
- Onshore Layout
- Afungi Project Site
- Near Shore Impact Extents



MAIN MAP SCALE:

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Kilometers

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Figure 11.3: Impact Extent Definitions Applied for the Near Shore

CLIENT:

Anadarko Moçambique Área 1, Lda

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DRAWN: AB	APPROVED: KG	SCALE: 1 : 230 000

DRAWING: Moz Maritime Baseline.mxd

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Impacto Projectos e Estudos Ambientais

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Projection: UTM Zone 37 S, Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation
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11.4 IMPACT OF DISCHARGE OF TREATED DRILL CUTTINGS AND RESIDUAL MUDS ON OFFSHORE BENTHOS AND DEEPWATER REEF ORGANISMS

11.4.1 Impact Assessment

Drilling muds will be separated from the drill cuttings using shale shakers, dried where necessary and returned to the drilling fluid system. The treated drill cuttings will then be discharged to the sea together with any residual muds (1). Two types of impacts from the discharge of treated drill cuttings and residual muds into the ocean from production well drilling may occur, namely:

- physical inundation (burial and change in sediment grain size) effects on benthic marine organisms (addressed in this section); and

- chemical toxicity effects on benthic and water column marine organisms (addressed as a separate impact in *Section 11.5*).

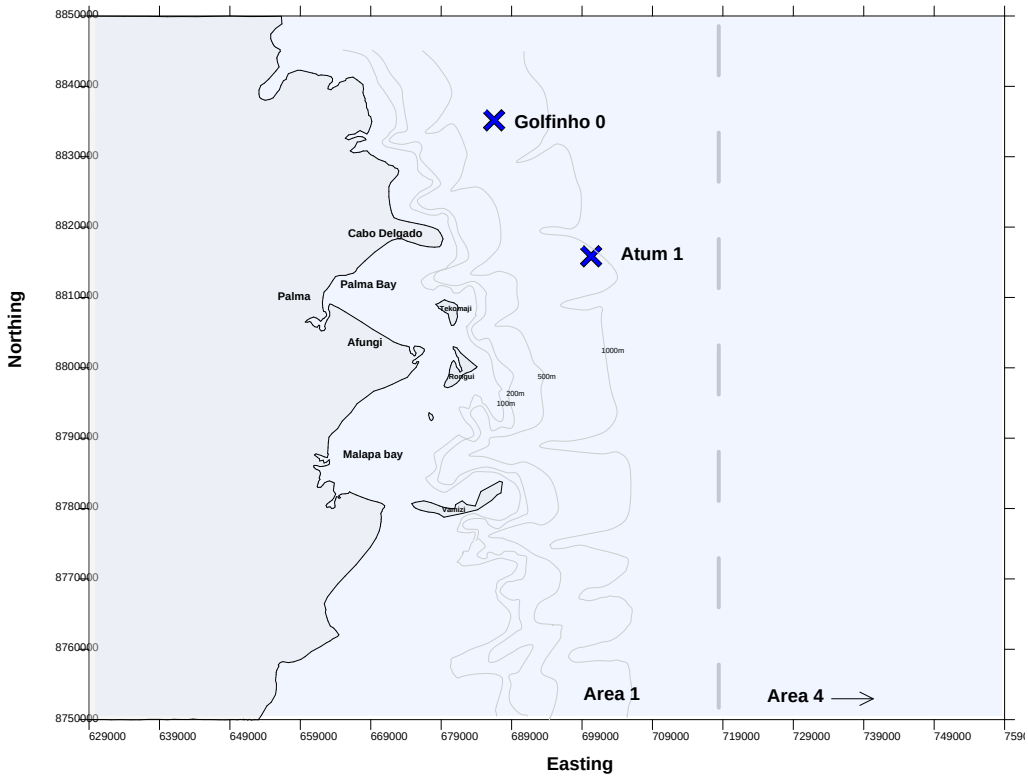
For a robust assessment of impacts, both types of impacts require knowledge about how the discharges will be dispersed once discharged into the marine environment. Results from dispersion modelling (2) of cuttings and muds behaviour, undertaken by Applied Science Associates Inc (ASA) as part of an investigation into the offshore gas fields conducted by CSA (2012), are used in this assessment. The model predicts the behaviour of discharged treated drill cuttings (coarse fraction) and residual drilling fluids (mud, fine fraction) in terms of convective descent, dynamic collapse and far field dispersion phases of sediment plume behaviour. The model outputs include sedimentation thickness gradients with distance from the discharge points.

ASA modelled treated cuttings and residual drilling fluids discharges at two locations offshore: Atum 1 in the Prosperidade Gas Field and Golfinho O in the Golfinho Gas Field. Golfinho O has been taken to represent the expected conditions in the Golfinho Gas Field, whilst Atum 1 represents the expected conditions in the Prosperidade and Mamba gas fields.

The respective locations of Atum 1 and Golfinho O and relative to the coastline and main bathymetry are shown in *Figure 11.4*.

(1) The optimum alternative solution for the final disposal of cuttings will be further investigated and GIIP will be applied.
(2) The modelling platform employed for the dispersion modelling was MUDMAP. This was developed by ASA and has numerous applications in drill cuttings discharge investigations, to the point where it may be regarded as an industry standard.

Figure 11.4 Potential Well Locations for which Treated Drill Cuttings Discharge Modelling was Conducted



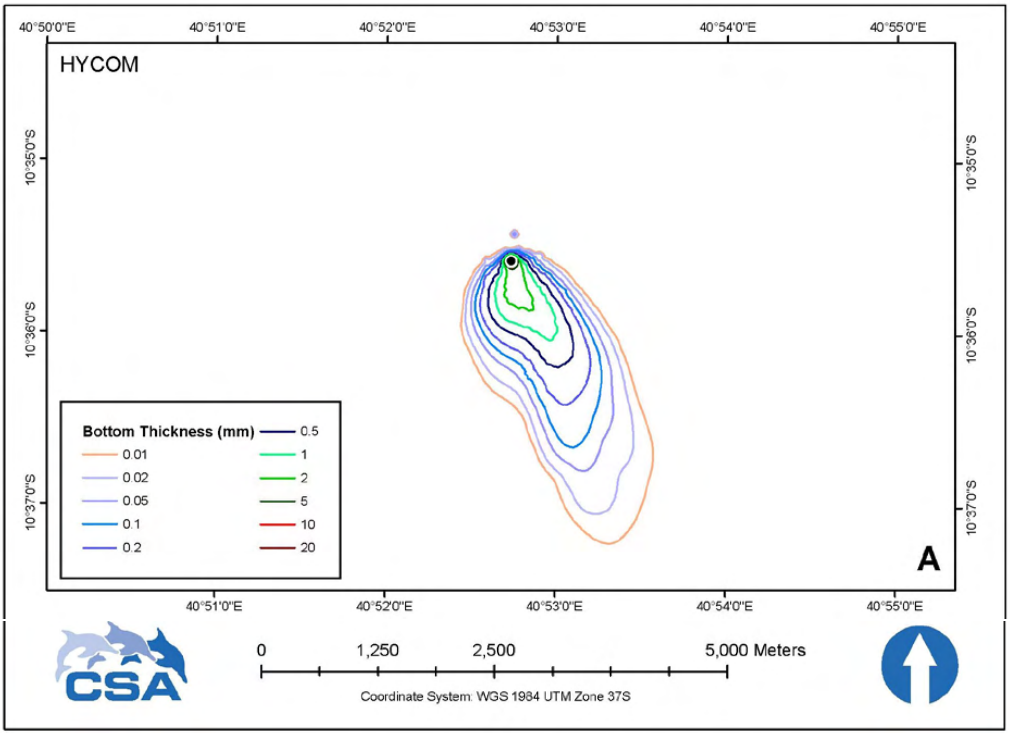
Note: The vertical dashed line delineates the boundary between Area 1 and Area 4.

Source: ASA in CSA, 2012.

Currents for each of the modelled sites were abstracted from the HYCOM data set for 2011, as detailed in *Chapter 7*. The model outputs are shown in *Figure 11.5* and *Figure 11.6* for Atum 1 and Golfinho O respectively.

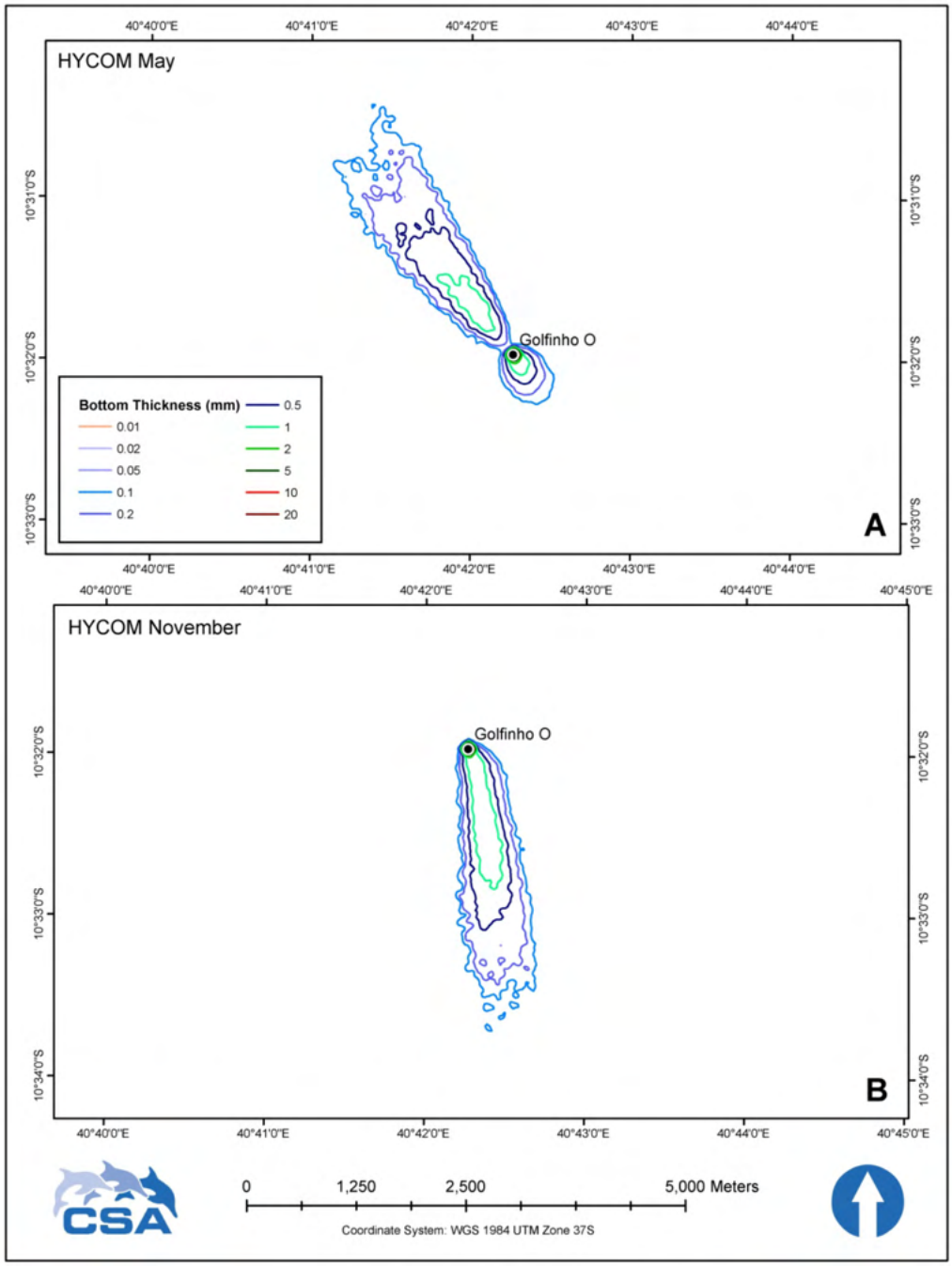
The plots of the predicted treated cuttings deposition show that the expected pattern is a narrow elipse aligned with major current vectors. This is most apparent for the Golfinho site (*Figure 11.6*), which experiences an apparent seasonality in currents, possibly due to its location near the bifurcation point of the Southern Equatorial Current (SEC) near the African landmass (described in *Chapter 7*). This results in switching between predominantly northward and southward flows, and the response is a cuttings deposition elipse aligned north-west in the period of northerly flows (May) and aligned almost due south during the period of southerly flows (November).

Figure 11.5 Modelled Drilling Cuttings and Residual Mud Deposition Footprint for the Atum 1 Well Site



Source: ASA in CSA, 2012.

Figure 11.6 Modelled Drilling Cuttings and Residual Mud Deposition Footprint for the Golfinho O Well Site in May 2011 (Top) and November 2011 (Bottom)



Source: ASA in CSA, 2012.

As shown in the above figures, the predicted total deposition footprints extend approximately 3km from the location of the well sites. There is a marked gradient in deposition depths within the footprints. However, most of the depositing material is confined to areas close to the well sites, due to deposition from the top-hole portion of the drilled wells (ie top-hole cuttings) that is ejected at the seafloor. This is coupled with the fact that the bulk of the discharges are medium sand-sized or larger rock chippings, as these have a high sedimentation velocity and therefore deposit close to the point of discharge.

As described in *Chapter 4*, up to 120 production wells may be drilled within the Offshore Study Area, namely within the Golfinho, Prosperidade and Mamba gas fields. Based on the dispersion modelling results from the Atum 1 and Golfinho O wells, the cumulative area deposition footprints for the total number of wells planned in each of the gas fields is projected to be (1) :

- Prosperidade and Mamba Gas Fields:
  - total footprint (>0.01mm) = 226km^2;
  - deposition to >1mm = 95km^2; and
  - deposition to >10mm = <1km^2.

- Golfinho Gas Field (2):
  - total footprint (>0.01mm) = 126km^2.
  - deposition to >1mm = 17km^2; and
  - deposition to >10mm = <1km^2.

The combined deposition footprints for the three gas fields at full production are:

- total footprint (>0.01mm) = 352km^2;
- deposition to >1mm = 112km^2; and
- deposition to >10mm = 1km^2.

Benthos living in and/or on unconsolidated sediments within the zone of deposition may be inundated by treated discharged cuttings and/or residual drilling muds, leading to smothering effects due to the clogging of respiratory and feeding apparatus by fine sediments (residual drilling mud fraction). This may result in benthos mortality and possibly altered benthos communities, with implications for higher levels in the marine food chain such as demersal fish and their predators. In addition, the settlement of organic-rich treated synthetic-based muds (SBM) cuttings on the seabed may result in a localised increase of nutrients in the footprint area. This may encourage microbial growth and organic decay, affecting oxygen levels, and may have the potential to impact benthos production. However, given the water depths in the gas fields and the predicted depths of the drill cuttings (including muds) and extent of the footprint area, potential impacts related to oxygen depletion on benthos are not likely to occur from a localised increase of nutrients.

Currently, there are no available quantitative regional data showing whether there are unique biological communities on the seabed. Remotely Operated Vehicle (ROV) surveys around current meter deployment sites in the offshore gas fields show varying degrees of bioturbation in the form of sediment mounds, but few megafauna (animals >10mm) on the sediment (see *Chapter*

(1) These calculations are based on the assumption of 60 wells in Prosperidade and Mamba Gas Fields, and 60 wells in Golfinho Gas Field. However the exact total per gasfield is yet to be confirmed.
(2) Based on the mean of May and November 2011 predictions.

7). However, given that most marine invertebrates reproduce through broadcasting eggs and sperm and there is usually a pelagic larval stage in the life history before settlement into benthic habitats, it can be assumed that there is at least a regional distribution of the fauna. This is supported by large-scale species richness gradients across multiple degrees of latitude for benthic fauna, reported by Macpherson (2002).

In near shore environments, the major classes of benthos living in and on the sediments (Mollusca, Crustacea and Annelida) can withstand instantaneous burial by up to 30cm of sediment, due to their abilities to migrate upwards through the sediment pile (Maurer et al., 1980; 1981; 1982). Therefore, any deposition of sediment of less than 30cm is unlikely to generate mortalities due to inundation. Near shore sediments are subject to redistribution by wave action and strong tidal flows, etc. However, this does not apply below the storm wave base in deeper waters (70 to 200m for extreme waves) (Sherwood et al., 1994), as mechanisms are not available there to redistribute the sediments.

Smit et al. (2008) analysed benthos species sensitivity to burial by drill cuttings and muds in a continental shelf environment from a database consisting of 39 effect values for 32 benthos species, which included molluscs, crustaceans and polychaetes. The derived minimum (EC_5 (1)) and median (EC_{50} (2)) effect concentrations for instantaneous burial depths were 6.3mm (95 percent confidence intervals 3.1-10.6mm) and 54mm (95 percent confidence intervals 37-89mm) respectively. However, the nature of drilling and drill cuttings disposal precludes instantaneous burial effects of benthos in the offshore area as the cuttings are discharged over the full period of production drilling, at an anticipated frequency of one well every 70 - 75 days. This gradual deposition allows the fauna to migrate upwards through the sediment pile as it deposits. Therefore, the Smit et al. (2008) EC_5 value is considered extremely conservative for drilling applications, and the EC_{20} (3) is taken to be a more realistic threshold. From the data presented in Smit et al. (2008), this equates to a burial depth of approximately 10mm.

Recovery from disturbance is reported to be variable and is also linked to the degree of bioturbation and associated redistribution of fine sediments. Gates and Jones (2012) report the presence of burrowing crabs (*Geryon*) within 5m of an exploration well (drilled with water-based drilling mud) three years after drilling. This implies that at least macrobenthos (>1mm fauna) may recover from the effects of drill cuttings and mud discharges within a three to five-year period in zones of high deposition (>10cm) (Gates & Jones, 2012). Within the high deposition zones, effects on benthos distribution may be regarded as long term due to the degree of sediment property transformation.

(1) The concentration of material that is estimated to be effective in producing some chronic response in 5 percent of the test organisms.
(2) The concentration of material that is estimated to be effective in producing some chronic response in 50 percent of the test organisms.
(3) ie 20 percent of the benthos community may be affected if the deposition was instantaneous.

The sessile fauna present on reef structures that occur in the deepwater areas for which modelling was conducted, and for the seabed in the wider area of the gas fields in general (see *Chapter 7*), are considered to be widely distributed. For example, the deep (cold) water coral *Lophelia* has been recorded throughout the Atlantic Ocean and deepwater Gorgonia spp. have similarly wide distributions (WoRMS, 2012). However, these fauna are known to have slow to very slow growth rates (Roark et al., 2009; CORIS, 2012) and thus any damage that may be caused to them may have long-lasting effects, extending decades or longer. Similar types of fauna appear to occur on both high and low-relief reef structures in the Offshore Study Area. The low-relief structures appear to be more barren of macrofauna than the higher-relief areas (CSA, 2012). Low-relief reef structures are also apparently more ubiquitous than the high-relief reef structures, but this may be a result of the very restricted data set available (10 sites with restricted spatial coverage ROV video records, see *Chapter 7*). However, for the purposes of this assessment, high-relief reef structures are accorded a higher importance rating than reef structures with low relief.

There is little information available on the sensitivity of deepwater sponges, hard corals, soft corals, sea fans (Gorgonacea, Pennatulacea spp.), Crinoidea and other communities to sedimentation. CSA (2012) noted a thin sediment veneer on some of the deepwater reefs on which these fauna were observed in Area 1, implying that they will survive some level of sediment inundation although lethal and sub-lethal effect thresholds are not known. The sediment burial depth threshold reported for deepwater corals in Norway is 6.5mm (Larson & Purser, 2011). Observations on the deepwater coral *Lophelia pertusa* showed that although acute effects at this burial level were restricted (<1 percent mortality), chronic effects were observed in 42 percent of the experimental exposures (Larson & Purser, 2011). This was expressed as a reduction in the tissue covering of the coral skeletal material, likely a result of oxygen depletion of the tissues due to the degradation of organic material in the fine fraction [<63µm equivalent spherical diameter (ESD)] of drill cuttings. The generation of such effects of coral in the offshore gas fields may potentially lead to the proliferation of biofouling organisms on some corals – although, as mentioned above, there is a lack of information available of such effects on deepwater corals.

Effects to benthic and reef organisms such as those described above may be limited to burial by very fine sediments. In practice, this is probably unlikely to reach significant levels (up to millimetres), as very fine sediments are most easily dispersed by ambient currents. Inundation by the larger sediment sizes in drill cuttings discharges are considered to be a lower risk, due to the relatively low risk of oxygen depletion resulting from organic matter remineralisation (Larson and Purser, 2011). However, these may still have effects on benthic and reef organisms. The cumulative effects of repeated sediment inundation on *L. pertusa* were tested in experimental exposures and the species was shown to be resilient, although this may not be the case for other key stages of the life cycle (eg planktonic larvae).

Taking the above into consideration, the adopted thresholds for this assessment of effects on reef organisms are burial depths of 1mm for chronic non-lethal effects and 10mm for acute or lethal effects; ie an acute/chronic ratio of 10, and a no-effect threshold of <1mm. These are the same as those considered for sediment epifauna and infauna. Due to generally slow growth rates reported for deepwater reef organisms (Roark et al., 2009; CORIS, 2012), any effects are expected to endure for 10 to 100-year periods, or longer in the case of damage to some black coral (Antipatharian) species.

Benthos

Benthos within the deposition footprint of the discharged drill cuttings and drilling fluids will be exposed to the effects of burial (ie deposition >10mm) in a seafloor area approximating 0.008km^2 for each well. Here the EC_{20} threshold is interpreted as an acute (ie lethal) effect level, and therefore the effect is classed as being of high intensity and is likely to occur. The affected seabed area would be approximately 0.96km^2 (1). The impacted area remains within the defined onsite scale (see *Section 11.3*). Impact magnitude will be low and impact significance will be MINOR.

Reef Organisms

Reef structures and their associated biological communities in the Golfinho and Prosperidade gas fields, and in the Mamba Gas Field - if present - will be placed at risk of enduring acute effects of inundation from discharged drill cuttings and drilling fluids. The reefs at risk would be those within the >1mm deposition layer, as it is considered in a worst case, that any sub-lethal effects on corals may have indirect consequences. For example, the development of biofouling communities on affected corals may eventually cause the smothering and death of corals. Simulation modelling indicates that the respective risk area is approximately 0.93km^2 at each well location. However, from observations it is clear that reef structures in the Golfinho and Prosperidade gas fields are small, isolated structures (and this is likely to be similar of those in Mamba Gas Field if present), so the actual affected areas are predicted to be much smaller than the predicted deposition footprint.

The recovery of reef communities that may be affected would take appreciable time, due to generally slow growth rates. Therefore, acute impacts would extend to the long term. Given the extent of the full suite of production wells to be drilled in the offshore gas fields is 120, the spatial extent of this impact is predicted to be 112km^2. Actual reef structures at risk are estimated to be 10 percent of the total areas of the respective deposition footprints, ie 11km^2 (derived from CSA, 2012 and current meter site surveys in Area 1) and thus, the extent of the impact is local. It should be noted that both the high and low-relief structures largely comprise scattered rock and sediment, and do not

(1) 0.008 km^2 per well and a total of 120 wells.

apparently support high densities of fauna (as detailed in *Chapter 7*). Therefore, the extent of the impact to reef organisms is largely reduced. The intensity of the impact could be high. The magnitude of the impact is considered to be medium and, given that the impact is likely to occur, the significance of the impact will be MODERATE.

The level of confidence in the predictions about the effects of physical inundation on marine organisms in the offshore gas fields is low to medium, as information about the biological communities on the seabed at these depths is currently inadequate, as is information about the recovery rates of these organisms from such disturbances.

11.4.2 Mitigation Measures

Benthos

The objective of the mitigation measure outlined below is to reduce as far as practically possible the extent of the deposition footprint on the seafloor of the discharged treated cuttings and residual muds to >1mm.

- Employ a subsurface discharge chute extending to approximately 10 to 15m depth for the overside disposal of treated drill cuttings and residual muds (1). This will reduce the size of the deposition footprint that is 1mm threshold is reduced.

Reef Organisms

The objective of the mitigation measures outlined below is to minimise the risk of generating acute effects on reef communities by avoiding discharging cuttings and drilling fluids in close proximity to high-relief reefs, and thereby to reduce the intensity of any impacts.

- Residual discharges of treated drill cuttings and residual muds should be restricted to distances of >500m from deepwater high-relief reefs as determined by ROV video surveys.

11.4.3 Residual Impacts

Benthos

The use of a subsurface discharge chute will promote the integrity of the initial density flow of the discharged cuttings, allowing deeper penetration before the onset of the lateral advection phase at the level of neutral buoyancy and helping to reduce the footprint of the impact, although it will still remain as onsite. The impact significance will remain as MINOR.

(1) This will promote the integrity of the initial density flow of the discharged cuttings, allowing deeper penetration before the onset of the lateral advection phase at the level of neutral buoyancy.

Table 11.2 Impact of Physical Inundation by Treated Drill Cuttings and Residual Muds on Offshore Benthos and Deepwater Reef Organisms

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Long term	Long term
Extent	Onsite	Onsite
Intensity	High	High
Magnitude	**Low**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MINOR**	**MINOR**
Operational Phase: N/A		

Reef Organisms

The discharge of cuttings and drilling fluids away from high-relief reef structures will reduce impact intensity and magnitude to medium and low respectively. The significance of the impact of physical inundation by drilling cuttings and residual muds on reef structures and associated organisms will be reduced to MINOR significance.

The level of confidence in the impacts to benthos and reef organisms is low to medium, as information about the biological communities on the seabed at these depths is currently inadequate, as is information about the recovery rates of these organisms from such disturbances.

Table 11.3 Impact of Physical Inundation by Treated Drill Cuttings and Residual Muds on Offshore Reef Organisms

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Long term	Long term
Extent	Local	Local
Intensity	High	Medium
Magnitude	**Medium**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MODERATE**	**MINOR**
Operational Phase: N/A		

11.5 WATER QUALITY IMPACTS ON OFFSHORE MARINE ECOLOGY FROM DISCHARGED TREATED DRILL CUTTINGS AND RESIDUAL MUDS

11.5.1 Impact Assessment

Toxicity effects on benthos and organisms in the water column and potential contamination effects of high food value organisms eg shellfish and fish, through flesh tainting may be caused by the chemicals associated with discharged drilling cuttings containing residual muds. Three categories of drilling muds/fluids are to be used for drilling activities in the Golfinho, Prosperidade and Mamba gas fields: water-based muds (WBMs), used to drill

the upper portions of a well; and SBMs or low toxicity oil-based muds (LTOBMs) to drill deeper portions.

Water-based Muds

WBMs are generally considered to be the least toxic of the drilling muds (Patin, 1999), although they do contain heavy metals in the barite component. Low-metal WBMs have been tested for solubility of the metals in sea water and the pore water of marine sediments by Crecelius et al. (2007, cited in Impacto Lda, 2008). Their laboratory tests indicated that mercury and other heavy metals are not released in significant quantities into sea water or pore water, and concluded that it is not likely that low-metal barite will cause environmental effects to organisms living in the water column. Further, experimental and field studies have shown that acute toxic effects of WBMs can be manifested only at high concentrations, and are only found within a few metres of the discharge point (Patin, 1999, cited in Impacto, 2008).

Due to the absence of a riser system during the drilling of the uppermost portions of a well, drill cuttings and the WBMs will be discharged directly to the seabed. This is standard industry practice and is largely accepted by environmental protection authorities globally, providing the concentrations of mercury and cadmium in the barite do not exceed 1mg/l and 3mg/l respectively. It is assumed that the barite used for drilling will comply with this specification; eg as per those of the United States Environmental Protection Agency (USEPA). Based on this, toxicity effects on marine organisms from discharged WBMs would be of a low intensity, restricted to the duration of the discharge during the initial approximately 15 percent of the period of well drilling (Impacto, 2008), and localised to the well site. Owing to the density of the mixture, any effect of increased turbidity on the water column above is unlikely.

Synthetic-based Muds

SBMs comprise synthetic components such as esters, paraffins and olefins, which are generally less toxic than oil-based muds (OBMs) due to reduced concentrations of aromatic compounds. Tests on SBMs have shown them to be practically non-toxic to marine organisms (Patin, 1999). SBM impacts on the water column when discharged with cuttings are generally considered to be negligible, due to their low solubility in sea water and the intermittent and transient discharge patterns adopted (OGP, 2003, cited in Impacto, 2008).

The SBMs expected to be used for production drilling are characterised by a polyaromatic hydrocarbon (PAH) content of less than 0.001 percent and a total aromatic content of less than 0.5 percent (OGP, 2003), as required by the USEPA, for example. The cuttings and muds abstracted are returned to the drilling rig where they are separated by shale shakers. The SBMs are recycled while the cuttings are discharged to sea after treatment to meet good international industry practice. A residual volume of SBM remains on the cuttings.

Due to low solubility, linked low toxicity effects, intermittent discharge and low residence time in the water column, it is likely that encounter rates with filter feeding pelagic fish will be low and therefore assimilation of tainting compounds, eg hydrocarbons, into fish flesh should be correspondingly low, if it occurs to any measurable extent at all.

Low Toxicity Oil-based Muds

LTOBMs are used for drilling activities in some parts of the world, such as the OSPAR Convention's maritime area; they are only in formulations designed for zero-discharge where all the used mud is either recycled (usually onshore) or re-injected with cuttings into the rocks below the seabed. It is assumed that any LTOBMs used for drilling in the offshore gas fields of Area 1, or the Mamba Gas Field of Area 4, will comply with Good International Industry Practise (GIIP) such as the UK Revised Offshore Chemical Notification Scheme in terms of OSPAR (see http://www.cefas.co.uk/ocns).

Accordingly, it is anticipated that the mud components will be of inherently low toxicity to marine organisms, and it is therefore highly unlikely that significant negative impacts will occur as a direct result of routine drilling activities by the Project.

Any impacts on marine organisms from the discharge of drill cuttings with residual fluids/muds adhered to these, are predicted to be of a low intensity, because of the low toxicities of the quantities and types of muds used/or input to the offshore environment. Any effects to benthos will be short term, as benthos recovery rates are within this time scale (ie months to years) (eg Newell et al., 1998) and recovery from effects in the water column will be faster (days for phytoplankton to months for zooplankton) (Parsons et al., 1977). Similar to hydrocarbons that may be discharged with synthetic based muds (described above), discharges of residual LTOBMs will be intermittent and as the hydrocarbon components are particle reactive (eg OGP, 2005) they should transit the water column rapidly with the sinking drill cuttings. Accordingly, although possibly of higher fish impact potential, the probability of generating tainting effects on filter feeding fish populations in the water column is low. Flesh tainting in the benthic environment should be limited to organisms foraging in the area of the drill cuttings deposition. These would be deposit feeders, eg some species of polychaete worms, molluscan nudibranchs etc., as opposed to fish that may form part of any fishery. Thus although tainting may possibly occur effects on fish flesh quality for human consumption are considered to be negligible.

Impacts from discharges are judged to be of low magnitude, and as impacts effects to benthos are likely to occur, impact significance will be MINOR.

The degree of confidence in the predictions about the impacts on marine organisms from toxic effects is medium, because information about biological communities on the seabed at these depths is limited.

11.5.2 Mitigation Measures

The objective of the mitigation measures outlined below is to reduce the intensity of effects on benthos by reducing levels of toxicity in the discharges.

- The drill rigs will be designed in accordance with GIIP to have an efficient solids control and mud recirculation system, including shakers, mud cleaners, dryers and centrifuges for the treatment of drill cuttings.

- WBMs and low toxicity additives should be used whenever possible (eg concentrations of mercury and cadmium in the barite should not exceed 1mg/l and 3mg/l respectively).

- SBMs and LTOBMs that are low in toxicity, biodegradable and do not bioaccumulate will be used (eg PAH content of less than 0.001 percent and a total aromatic content of less than 0. 5 percent).

- All chemicals used should conform with the revised Cefas Offshore Chemical Notification Scheme (1) and OSPAR's PLONOR (pose little of no risk) list of substances (2).

- Treated cuttings discharged into the sea will have a maximum oil concentration in accordance with GIIP.

11.5.3 Residual Impact

The use of low toxicity drilling fluid components and the adequate treatment of cuttings before discharge will reduce hydrocarbon concentrations and the intensity of any effects, as toxicity risks will be minimal. Impacts are evaluated to be of negligible magnitude and NEGLIGIBLE significance to marine organisms.

Table 11.4 Impact of Toxicity Effects on Water Column, Seabed and Offshore Marine Ecology from Discharged Treated Drill Cuttings and Residual Muds

	Without Mitigation	**Residual Impact (with Mitigation)**
Construction Phase		
Duration	Short term	Short term
Extent	Onsite	Onsite
Intensity	Low	Negligible
Magnitude	**Low**	**Negligible**
Likelihood	**Likely**	**Unlikely**
Significance	**MINOR**	**NEGLIGIBLE**
Operational Phase: N/A		

(1) http://www.cefas.defra.gov.uk/industry-information/offshore-chemical-notification-scheme.aspx
(2) http://www.ospar.org

11.6 IMPACTS OF DISCHARGE OF HYDROTEST WATER ON OFFSHORE WATER QUALITY AND MARINE ECOLOGY

11.6.1 Impact Assessment

Prior to commissioning, the structural integrity of the subsea system is determined using a hydrostatic pressure test, in which all pipelines are filled with water, pressurised above the intended operating pressure and monitored for leaks or pressure loss over a specified time period. Additives such as oxygen scavengers and biocides are often added (1) to the water as a preventative measure to control the risk of potential corrosion and micro–organism growth in the pipes.

After a pressure test is completed, the pressure is released and the pipelines dewatered by pushing a 'pig' through the line, using pressurised air or gas. The hydrostatic test process, including filling, testing and depressurising, can range from a few days to a few weeks, depending on pipe sizes and lengths. The discharged water typically contains the contaminants and particulate matter present in the pipelines and the additives. Additives are customarily used at concentrations of 1,000ppm. The Project proposes to release the hydrotest water into the sea at the major gathering manifolds distributed around the natural gas fields. The estimated volume to be discharged over the testing cycle is 120,700m^3, which will be released at approximately 9,500 litres/minute through the 22-inch diameter pipes and at approximately 4,900 litres/minute from the 16-inch diameter pipes. This equates to a discharge velocity of approximately 0.65m/s and an overall discharge period of 11-12 days if discharged continuously. It is more likely, however, that discharges will be discontinuous as segments of the infrastructure are tested.

The main factors that determine the composition of discharged hydrotest water are the characteristics of the source water, anti-corrosion additives, any residues not removed during flushing, and reactions occurring within the pipe during testing, such as corrosion. Constituents in the hydrotest water are mainly due to mill scale breakdown (eg iron oxides and traces of manganese and copper) and unreacted additives and their reaction products (eg inorganic salts such as ammonium bisulphite) when oxygen scavengers are used. Previous studies have shown that constituent levels in the used hydrotest water are generally not toxic, but that treatment is often required specifically to lower turbidity (which can attain 4,000 Nephelometric Turbidity Units or NTUs) and to raise dissolved oxygen levels (can be reduced to <1mg/l) (CSIRO, 2005).

The hydrotest water discharged at the major gathering manifolds distributed in the offshore gas fields at depths of approximately 1,000 – 2,300m is estimated at 120,700m^3. It may contain inorganic sulphite salts, residual biocides, dyes and may be turbid. This will compromise bottom water quality

(1) Trade products to be used include Pipetreat 2001, Aquahesive 5836 and Hydrosure Biocide Stick.

in the natural gas fields during commissioning ie the construction phase. It is predicted to occur as a number of events, ie short-term just before gas extraction starts. It will impact water quality at the onsite scale, but will have negligible or undetectable effects (negligible intensity) on marine ecology and/or marine ecological processes because of natural dilution processes (eg CSIRO, 2005). The magnitude of the impact to marine organisms is predicted to be negligible and, similarly, the impact significance is NEGLIGIBLE.

The degree of confidence in this assessment is medium, as there are no measurement data for the behaviour of discharged hydrotest water at the planned release depths – and such data would be extremely difficult to acquire. The final lengths of pipelines to be installed, and the constituents and quantities of additives to be used, are not yet known. The planned discharges would be a small fraction of the Desalination Plant discharges.

11.6.2 Mitigation Measures

The Project will consider the pollution prevention and control measures set out in the IFC EHS Guidelines for Offshore Oil and Gas Developments for the management of hydrotest waters. In accordance with these GIIP guidelines, the Project will prepare of a hydrotest disposal procedure that considers point of discharge, rate of discharge, chemical use and dispersion with the objective to maximise the dilution of the hydrotest water in the water column.

Hydrotest water shall be re-used/recycled in the process (ie to hydrotest the onshore facilities).

11.6.3 Residual Impact

A phased approach to the discharge of hydrotest water, with increased discharge pressure will ensure that the water quality effects of the discharges are restricted to close proximity of the release points in the offshore natural gas fields. The impact significance to marine organisms will remain as NEGLIGIBLE.

Table 11.5 Impact of Discharge of Hydrotest Water on Offshore Water Quality and Marine Ecology

	Without Mitigation	**Residual Impact (with Mitigation)**
Construction Phase		
Duration	Short term	Short term
Extent	Onsite	Onsite
Intensity	Negligible	Negligible
Magnitude	**Negligible**	**Negligible**
Likelihood	**Unlikely**	**Unlikely**
Significance	**NEGLIGIBLE**	**NEGLIGIBLE**
Operational Phase: N/A		

11.7 IMPACTS OF INCREASED NOISE, LIGHTING AND VESSEL MOVEMENTS ON OFFSHORE MARINE ECOLOGY

11.7.1 Impact Assessment

The additional vessels and helicopters employed either to establish the offshore systems (drilling, engineering work, security and services, etc) or to visit the LNG Facility or associated infrastructure during operations will, among other things, result in:

- increased quantities of ships' operational waste discharges to sea; and
- increased noise, lighting and vessel movements (the latter with the risk, however unlikely, of collisions with whales).

The direct or indirect discharge or disposal to sea of solid waste, liquids, gases and particulates is regulated through national and international law. Specifically applicable is the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), to which Mozambique is a signatory. Accordingly, it is assumed that all Project vessels will be MARPOL 73/78 compliant and that the law will be obeyed. Equipment will be used to ensure that no thresholds are exceeded to ensure no impacts of significance occur. Consequently, this aspect is not assessed further.

The potential impacts of vessel and helicopter noise, lighting and movement are not regulated to the same extent, and are assessed below.

Offshore vessels will be operational 24 hours per day during construction (for approximately 18 months). During operations, shipping levels offshore in the gas fields will be much lower. The noise emitted by vessels may affect the movements and behaviour of marine fauna. Noise from helicopters travelling between the LNG Facility and the offshore vessels may also disturb turtles, marine mammals and seabirds. In addition, lighting from the vessels may attract and disorient certain species, in particular migrating birds and some fish species, which may then be more easily preyed upon by other fish and by seabirds. There is an abundant whale fauna in the Offshore Project Area in the vicinity of the gas fields, and fast-moving vessels may collide with individual whales, causing serious injury and usually mortality.

The area of potential impacts on any marine fauna is localised to the vicinity of the vessels and is limited to the short-term duration of construction and commissioning. Excluding injuries to whales, even in severe cases of disturbance, only a chronic effect on a minute proportion of fish, squid, turtle and/or bird populations concerned may occur. The potential impact is therefore evaluated to be of NEGLIGIBLE significance. The effects of vessel collisions with or disturbance to whales may be more severe, due to their conservation importance. Accordingly, the extent of the impact of vessel collisions with whales can be considered international. The intensity and magnitude could be high at both individual whale and whale population

level. However, as impacts are unlikely to occur, the associated impact is predicted to be of MODERATE significance.

The degree of confidence in this assessment is medium, because the behaviour of vessel crew members cannot be predicted.

11.7.2 Mitigation Measures

The objective of the mitigation measures outlined below is to reduce harmful interactions with marine organisms by reducing noise, lighting and vessel speed.

- Develop a Marine Mammal Observation Procedure (MMOP) that addresses, at least, the need for trained marine mammal observers (MMO's), record keeping, vessel movement, light, noise, avoidance strategies and helicopter traffic. Specific measures to be included are outlined below.
    - Reduce travelling speeds if whales, dolphins or turtles are encountered, to afford the animals the opportunity to move out of the way.
    - Trained MMOs will be present during drilling and construction works in the area of the subsea infrastructure to keep a watch for the presence of marine mammals and turtles. They will record sightings to assist research and to plan additional avoidance strategies.
    - If any species of marine mammals, particularly whales, are sighted near the path of a vessel, the vessel will gradually divert to avoid the marine mammal or slow down to idling speed, if this can be done safely.
    - Instruct helicopters to maintain a minimum height of 500m over bird foraging areas, surfacing cetaceans or groups of turtles, and prohibit circling or hovering over marine mammals (eg for casual viewing) unless essential for safety or emergency purposes.
    - Minimise non-essential lighting on vessels, and shield and/or reduce the number of lights shining directly onto the water as far as possible.
- Keep any disoriented but otherwise unharmed seabirds found on vessels at night in dark containers and release them during daylight. Any ringed/banded birds found on vessels should be reported to the appropriate ringing/banding scheme.
- Prohibit all crew members from killing or causing injury to marine fauna (any crew members found to have deliberately killed or caused injury to marine fauna shall be dismissed immediately and removed to shore).

- Undertake environmental awareness training of all crew members, which includes training on the conservation status of cetaceans and turtles.

11.7.3 Residual Impact

The mitigation measures will help to reduce the effects on individual organisms and could reduce the probability of any impact occurring. The impact significance is of NEGLIGIBLE significance for fish, squid and/or bird populations. The specific whale mitigation measures outlined above will ensure that vessel collisions with whales are avoided, and thus impact significance is reduced to NEGLIGIBLE.

Table 11.6 Impact of Noise, Lighting and Vessel Movements on Offshore Marine Ecology

	Without Mitigation	**Residual Impact (with Mitigation)**
Construction Phase		
Duration	Short term (whales long term)	Short term
Extent	Onsite	Onsite
Intensity	Low (whales high)	Low
Magnitude	**Negligible (whales high)**	**Negligible**
Likelihood	**Likely (whales unlikely)**	**Unlikely**
Significance	**NEGLIGIBLE (whales MODERATE)**	**NEGLIGIBLE**
Operational Phase		
Duration	Short term (whales long term)	Short term
Extent	Onsite	Onsite
Intensity	Low (whales high)	Low
Magnitude	**Negligible (whales high)**	**Negligible**
Likelihood	**Likely (whales unlikely)**	**Unlikely**
Significance	**NEGLIGIBLE (whales MODERATE)**	**NEGLIGIBLE**

11.8 IMPACTS OF STRUCTURES MODIFYING HABITATS ON THE OFFSHORE SEABED

11.8.1 Impact Assessment

The impact assessed in this section is of the changes to the character of the seabed by adding hard substrate (subsea infrastructure), which will result in changes to benthos community structure, ie it may crush some organisms and provide an altered habitat for colonisation by others.

The Subsea Production System of Pipeline End Termination Structures (PLETs), trees, manifolds, pipelines, umbilicals and carbon steel mudmat supports will be installed over an area of 350km^2 on the seabed. Items will be lowered through more than a kilometre of water onto the seabed by DP vessels on the sea surface, with the assistance of ROVs. Final locations and layout will be defined as reservoir engineering work continues. The subsea system will be operated via electro-hydraulic controls from onshore within the LNG Facility.

Cementing of the casing in the upper sections of the wells may result in a release of excess cement from the top of the wells into the marine environment. Such spilled cement would settle on the seafloor and may

smother benthic marine life in the vicinity of the wells, although volumes are likely to be very small.

The placement of the approximately 1,100,000m^2 (1.1km^2) of hard metallic structures and interconnecting pipelines on the seabed and deposition of top-hole cuttings from approximately 120 wells (120 x 0.0003142km^2/well = 0.4km^2) will permanently modify the seabed environment. The extent of the impact would be onsite and at a low intensity, because disturbances would be relatively isolated and located in an extensive undisturbed area of more than 1,000km^2 within Area 1 and Area 4. However, a minor proportion of this area may host deepwater reef structures with corals, tunicates and other sessile fauna. As most of the area appears to be homogeneous sand/muddy sand/mud, these low to high-relief reef structures will probably be vital habitats, particularly for deepwater fish. Damage to these features could have important effects on the natural biodiversity of the region. Any impacts to reef structures would be of a similar scale and duration to those identified above. However, the impacts will be of high intensity and magnitude, and there will be definite changes to the benthos community, and the associated impact is predicted to be of MODERATE significance.

The degree of confidence in this assessment is high, based on previous experience of introducing new infrastructure into the marine environment.

11.8.2 Mitigation Measures

The objective of the mitigation measures outlined below is to reduce the intensity of effects and to cause as little disruption as possible to sea life and shipping.

- Survey all candidate pipeline corridors by ROV and realign corridors if they intercept deepwater reef structures during construction.

- Survey all locations for subsurface infrastructure by ROV and avoid to the extent practical areas of high and low-relief deepwater reef structures.

- No mitigation measures are deemed necessary for the balance of the operations, although sound operational procedures would reduce the risk of unnecessary disturbance by the placement and movement of infrastructure on the seabed, or by dropped objects or accidental cement spills.

11.8.3 Residual Impact

During the construction phase, the residual impact would be confined to the addition of hard structures to the apparently vast area of unconsolidated sediments in the offshore gas fields. Impacts will be exerted at the onsite scale, and be permanent but of low intensity. Both the impact magnitude and the significance rating would be NEGLIGIBLE during the construction phase.

Table 11.7 Impact of Structures Modifying Habitats on the Offshore Seabed

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Permanent	Permanent
Extent	Onsite	Onsite
Intensity	High	Low
Magnitude	**High**	**Negligible**
Likelihood	**Definite**	**Definite**
Significance	**MODERATE**	**NEGLIGIBLE**
Operational Phase: N/A		

11.9 IMPACTS OF DREDGING-INDUCED TURBIDITY ON NEAR SHORE MARINE ENVIRONMENT (SEAGRASS, CORAL REEF AND ASSOCIATED BIOLOGICAL COMMUNITIES)

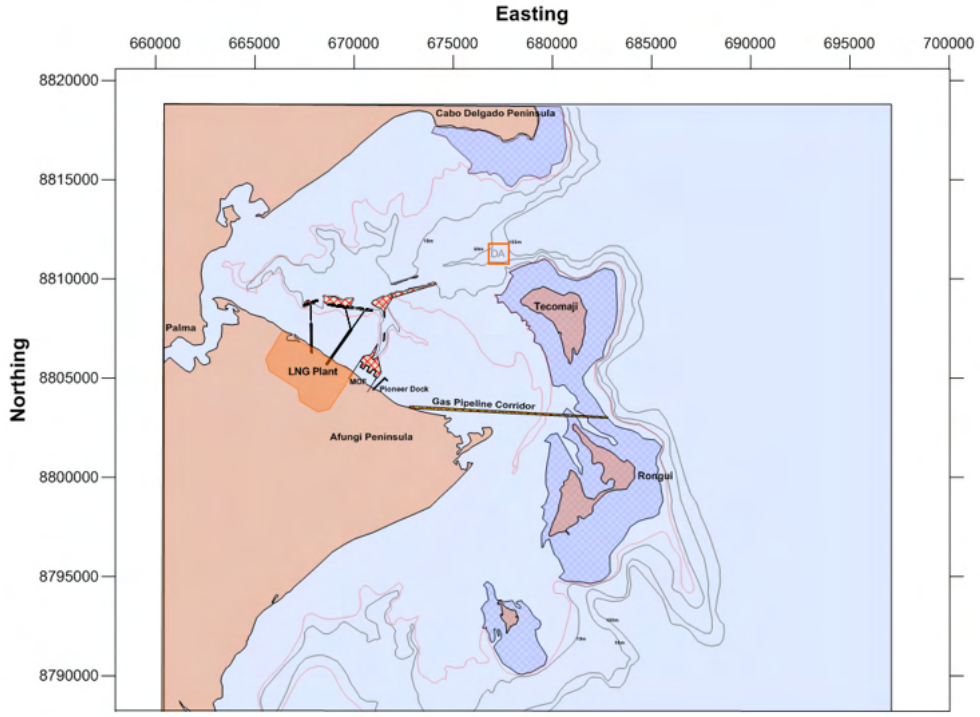
11.9.1 Impact Assessment

Capital dredging (1) will occur as part of the construction of the Pioneer Dock, the MPD, LNG Export Jetty, Dolphins and ship-turning circles, and gas import pipeline corridor. The estimated dredge volume associated with capital dredging is up to 11.9Mm^3. It is envisioned that up to two Cutter Suction (CS) Dredgers will be utilised, and may operate concurrently in the gas import pipeline corridor and the berth and shipping channel development areas. During the operational phase, there may be a requirement for maintenance dredging (2). Predicted maintenance dredge volumes will be small, because of the low sediment transport rates in Palma Bay (Moffatt & Nichol, 2011).

Dredge material from capital dredging is to be discharged to an onshore reclaim for the development of the MPD (up to approximately 7.0 Mm^3), with the balance (up to approximately 4.1 Mm^3) being disposed to sea (see *Chapter 4*). Dredge material from maintenance dredging will be disposed to sea. The identified area for offshore disposal is at the head of the Afungi Canyon. In both cases, the dredge material is to be pumped as a slurry from the dredgers to the placement area through pipelines. The on-land reclaim will dewater via a discharge to sea at the seaward end of the MPD. The reclaim will be designed such that suspended sediment concentrations in the discharge will be limited to approximately 100mg/l. The marine discharge will be through a pipeline lying on the seabed aligned down the canyon. The discharge depths will be between 50m and 70m. *Figure 11.7* shows a schematic view of the respective dredging and dredge material placement operations in Palma Bay.

(1) Capital dredging is the initial dredging to create a deeper harbour basin and a deeper navigation channel, and facilitate the construction of near shore infrastructure.
(2) Maintenance dredging involves the removal of generally naturally occurring siltation from channel beds to maintain the design depth of navigation channels and ports.

Figure 11.7 ***Proposed Dredge Areas for the Berths, Shipping Channels and Gas Import Pipeline Corridor and Dredge Spoil Disposal Site***



Source: Lwandle, 2012.

Key: Red hatching: shipping channels and gas import pipeline corridor. Red square: dredge spoil disposal site.

Dredging can result in increased turbidity in the following ways:

- by the action of the CS Dredger head in the dredge areas;
- at the dewatering point from the onshore reclaim; and
- at the offshore dredge placement area.

The latter is expected to be minimal and constrained to water depths >50m, as the discharged slurry will be denser than sea water and will tend to flow down the Afungi Canyon into deeper water.

Elevated turbidity affects underwater light distributions and increases particulate loads in the water column. A decrease in underwater light can affect primary producers including phytoplankton, macrophytic algae (seaweeds), seagrass and Zooxanthellae symbionts in corals through reducing light energy available for photosynthesis. Increased particulate loads in the water column typically interfere with filter-feeding organisms, bivalve molluscs such as clams and barnacles (crustacea), corals, some fish species, and fish in general through clogging of their gills. Near shore fish species are, however, resilient to relatively high suspended sediment concentrations – fish eggs can survive exposures to 100mg/l total suspended sediment (TSS), fish larvae 500mg/l and even sensitive species of adult fish 1,000mg/l over 24-hour periods (EMBECOM, 2004).

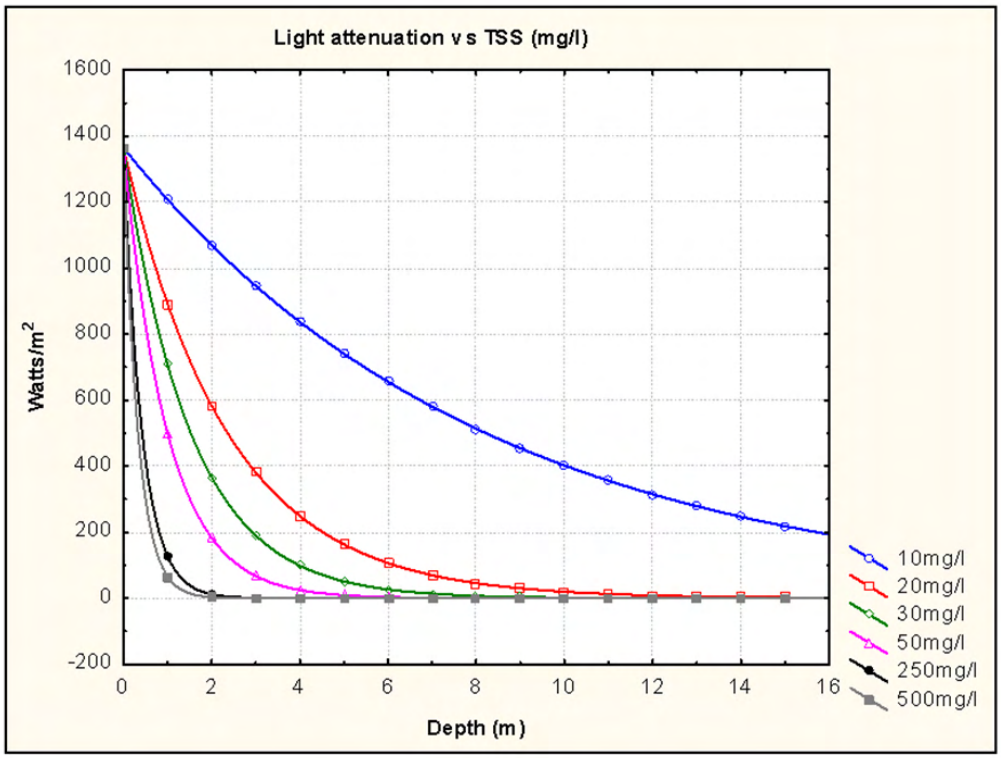
Important biotopes within Palma Bay are seagrass meadows and coral communities, as these comprise the majority of the biodiversity within the system and support artisanal fishing to a large extent. Seagrass beds extend to water depths of 6 to 8m, while corals extend to water depths of at least 35m. Underwater light level thresholds for seagrass and corals are broadly similar and lie in the range of 3 to 30 percent of surface irradiance (SI) for seagrass (Erftemeijer & Lewis, 2006) and 1 to 35 percent for corals (PIANC, 2010) (1).

A threshold of 25 percent SI is considered protective of both seagrass species present in Palma Bay, including *Halophila, Syringodium* and *Thalassia (*Erftemeijer & Lewis, 2006), and corals, especially massive, branched and plate species (PIANC, 2010). Findings from underwater light field monitoring and modelling in Australia has allowed the formulation of the percent SI/TSS relationships shown in *Figure 11.8*, and indicates that the equivalent TSS threshold concentration for 25 percent SI underwater light thresholds is 10mg/l, within the depth range of seagrass and most corals (Environmetrics Australia, 2007).

In terms of particulate loads, TSS concentration thresholds protective of most benthic organisms where no effects are observed are <20mg/l, exposures of 20-80mg/l for 72-hour periods may generate sub-lethal (chronic) effects, and exposures >80mg/l may generate lethal (acute) effects (EMBECOM, 2004). In contrast, effect concentrations given in PIANC (2010) indicate that corals may be sensitive to TSS concentrations below the no-effect level shown above. Therefore, the 10mg/l threshold derived for light attenuation is applied here, specifically for the highly diverse fringing coral reef around the Palma Bay islands.

(1) With the exception of branching corals which is 60 percent.

Figure 11.8 Light Attenuation versus TSS

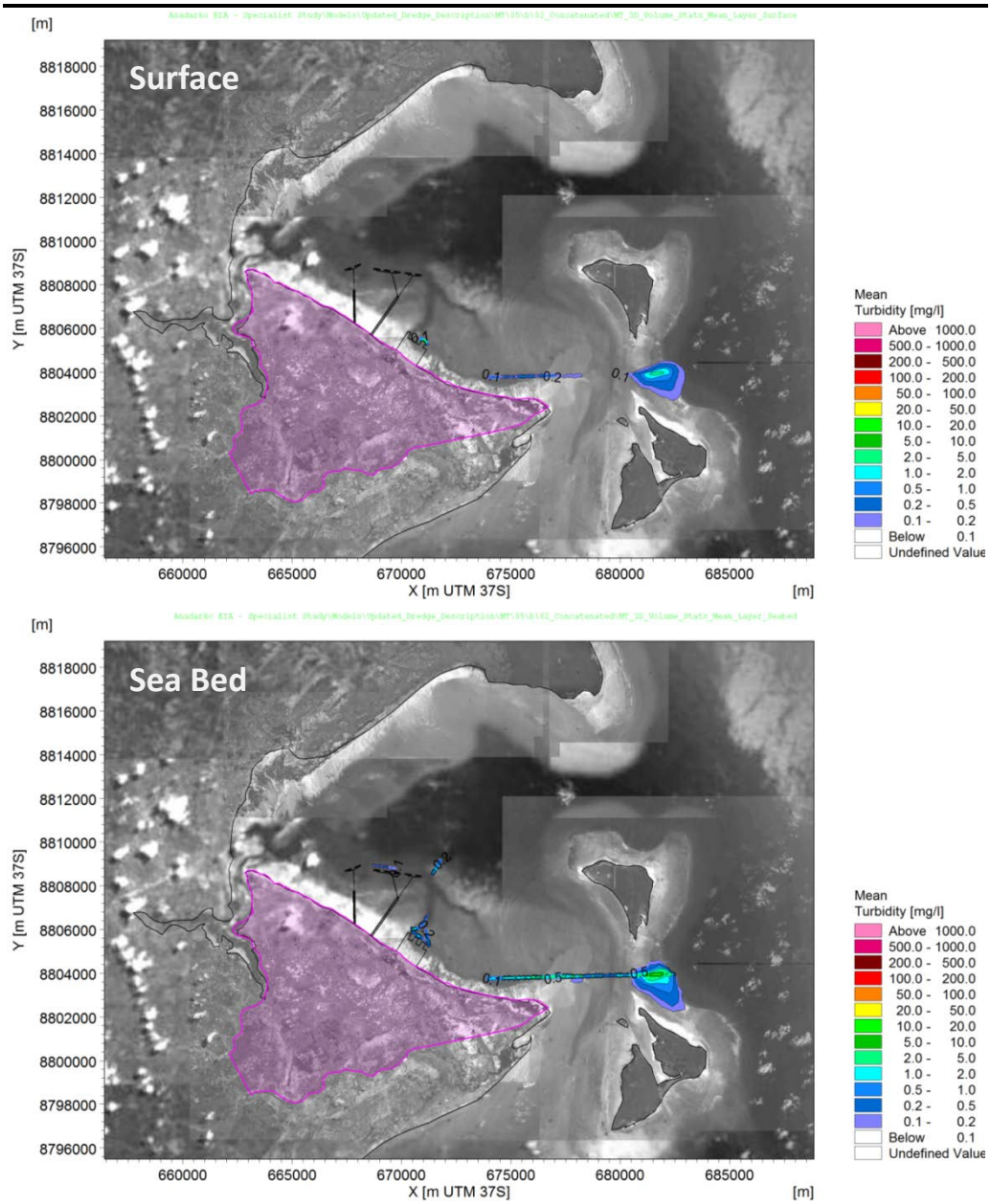


Source: Lwandle, 2012 compiled from data in Environmetrics, Australia (2007).

Turbidity plume distributions for the various turbidity sources (dredging of the offshore pipeline channel, deepening of the access channel for the MPD and Pioneer Jetty, dredging of the MPD turning basin and dewatering of filling operations for the LNG Export Jetty) were modelled for a 12-month period by PRDW (2012). A total of eight dredging scenarios were modelled, ranging from a single CS Dredger working either the pipeline corridor or the berth and shipping channel areas, to two dredgers working in tandem. The worst-case scenario presented by PRDW (2012) is that of two dredgers working in tandem, with concurrent material discharges to the land reclaim and the offshore placement areas. The statistical mean distribution and the predicted maximum concentrations in the modelled surface and bottom layers for this worst-case scenario are illustrated in *Figure 11.9* and *Figure 11.10*.

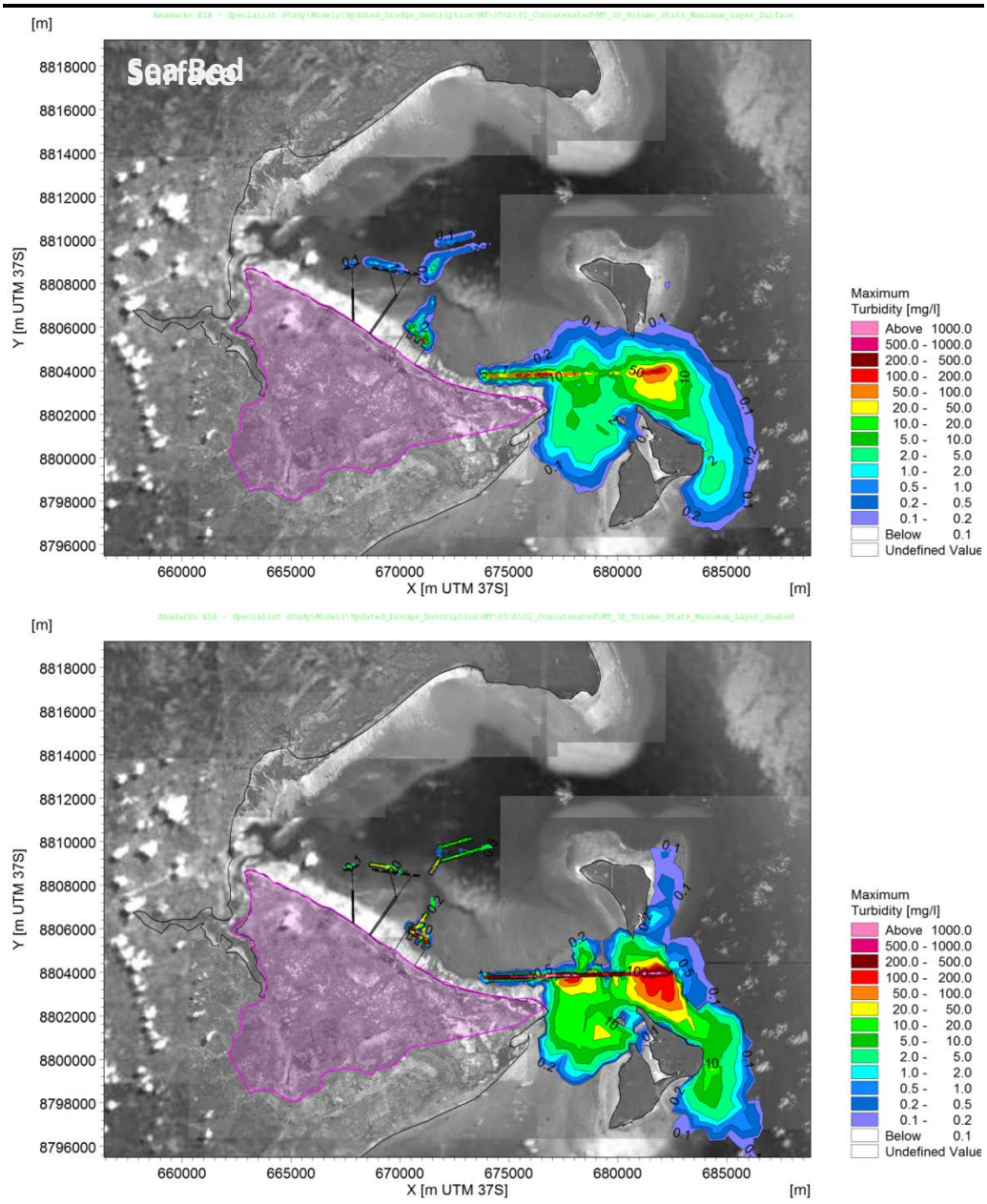
It is apparent that, in terms of maximum levels, turbidity at the seafloor is widely disbursed and attains very high levels adjacent to the dredged pipeline corridor. Turbidity flows from the reclaim, and those associated with dredging in the berths and shipping channel areas, although reaching similar intensities, are far more spatially constrained. As expected, the turbidity signal is considerably reduced at the sea surface, while the predicted mean TSS distributions are limited to the areas of direct disturbance (ie the dredge footprint).

Figure 11.9 Predicted Distributions of the Mean Concentrations of TSS for Surface (Top) and Seabed (Bottom) over a One-year Dredging Period



Source: PRDW, 2012.

Figure 11.10 Predicted Distributions of the Maximum Concentrations of TSS for Surface (Top) and Seabed (Bottom) over a One-year Dredging Period



Source: PRDW, 2012.

The modelled mean distributions show relatively low effects of turbidity at the sea surface and the seabed across all of the dredging areas and at the land reclaim discharge site. Suspended sediment concentrations in the surface layer do not exceed 10mg/l at any location, while at the seabed there is a minor exceedance at the offshore extent of the pipeline corridor (see *Figure 11.9*). In contrast, the modelled maximum concentrations (see *Figure 11.10*) show a larger area, where the suspended sediment concentrations exceed 10mg/l. At the surface, this occurs in the immediate vicinity of the land reclaim discharge and along much of the pipeline corridor. At the seabed, 10mg/l is exceeded in all of the dredge areas. However, at the berth and navigation channel locations, this is largely restricted to the dredging

footprint [1]. Along the pipeline corridor high concentrations occur more extensively, with extremely high suspended sediment concentrations (>1,000mg/l) predicted for the corridor itself and large areas adjacent to the corridor where concentrations may exceed 10mg/l.

Therefore, according to the predicted maximum suspended sediment concentrations distribution, appreciable proportions of the Palma Bay seagrass meadows and coral areas in the vicinity of the pipeline corridor may be at risk from elevated turbidity. Deleterious effects on these communities are exerted by the absolute concentrations and durations of exposure to elevated levels. Specifically to gain insight into the latter, aspect time series estimates of total suspended sediment concentrations over the modelling period were extracted from the model output for five sites in Palma Bay (*Figure 11.11*).

Comparison of their respective locations with the predicted suspended sediment concentrations in *Figure 11.11* and *Figure 11.12* show that only three of the sites (Palma Bay seagrass, pipeline corridor seagrass and pipeline corridor coral bommies) would be exposed to appreciable suspended sediment concentrations.

Figure 11.12 shows the temporal exposure patterns for these sites. The time series plots indicate that sites in the berth and shipping channel area may be exposed to elevated turbidity levels for periods extending to six months or more. However, the predicted mean and maximum turbidity levels in this location are low (mean values) and, even though the maximum values are high, elevated turbidities are spatially restricted (*Figure 11.9* and *Figure 11.10*). In the pipeline corridor, periods of high turbidity levels are predicted to be short in duration (*Figure 11.12*) so even though the spatial extent of the maximum turbidity levels is large, actual exposures within this are predicted to be episodic and of short duration (days).

(1) The dredging footprint is the area of the seafloor impacted directly by the action of the dredging operation.

40°25'0"E 40°30'0"E 40°35'0"E 40°40'0"E

10°40'0"S 10°45'0"S 10°50'0"S 10°55'0"S

CDG-FR

Cabo Delgado Peninsula

-5

DA

-100
-50
-10

Palma Bay

-10

SCs

Tecomaji Island

NFB

PC-FR

PC-Bs

Afungi Peninsula

PC-SG S

Rongui Island

-5
-10
-50
-100

Queramimbi Island

bing™

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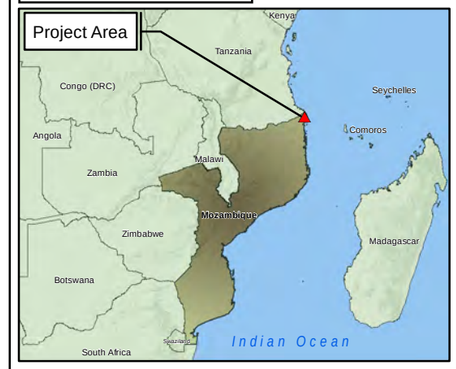
Legend

- Cabo Delgado Fringing Coral Reef Site
- Palma Bay Seagrass Site
- Pipeline Corridor Seagrass Site
- Pipeline Corridor Fringing Coral Reef Site
- Pipeline Corridor Coral Bommie Site
- Near Field Bommie (NFB)
- Regional Roads
- Proposed Nearshore Infrastructure
- Proposed Pipeline Corridor Route
- Fringing Reef (FR)
- Dredge Disposal Area
- Afungi Project Site

Bathymetry (Metres below Mean Sea Level)

- -5
- -10
- -50
- -100



MAIN MAP SCALE:

0 2 4 6

Kilometers

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TITLE:

Figure 11.11:
Locations for which Time Series of TSS Concentrations were extracted from the Turbidity Modelling

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 110 000
DRAWING: Turbidity Modelling.mxd		REV: A

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Tel: +27 21 681 5400
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Impacto Projectos e Estudos Ambientais

ERM

Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation. Lwandle Technologies, 2012. Inset Map: Esri Data & Maps

SIZE: A3

T:\GIS Projects\0133576_Anadarko_Moz_LNG\Mapping\MXD\ES\A\Chapter11\Turbidity Modelling.mxd

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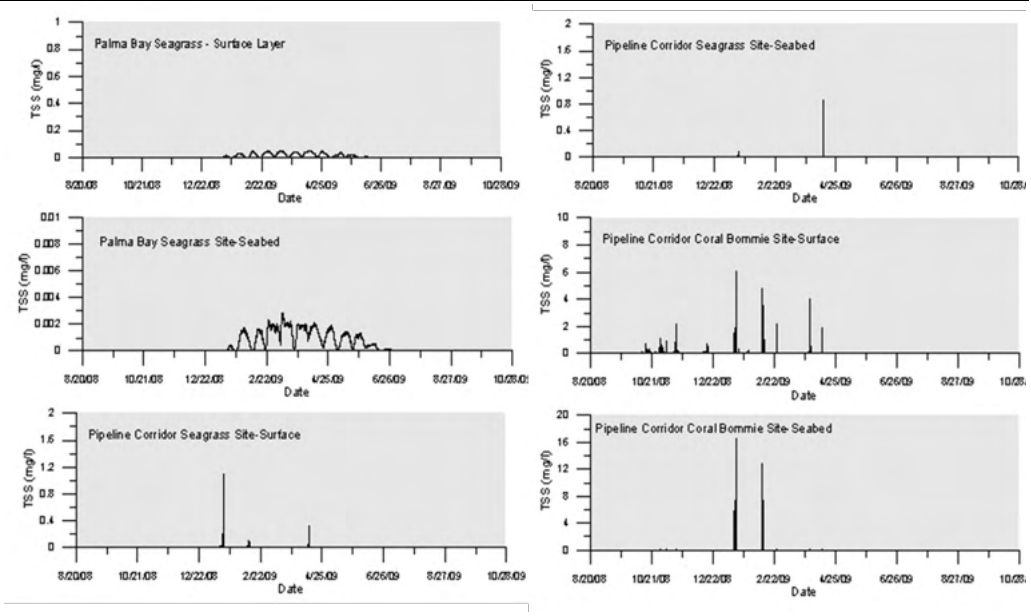
Figure 11.12 Modelled Time Series Distributions of TSS Concentrations in the Surface and Seabed Layers over One-year Dredging Period at Selected Sites in Palma Bay



Source: PRDW, 2012 and Lwandle, 2012.

Turbidity increases in Palma Bay due to capital dredging and, to a far lesser extent, maintenance dredging for the marine facilities may potentially reduce seagrass growth, deleteriously affect coral and coral reefs and compromise associated biological communities. Turbidity generated while dredging the pipeline corridor will likely be of high intensity, as suspended sediment concentrations are predicted to exceed the defined response threshold of 10mg/l and may affect the high biodiversity fringing coral reefs and coral bommies around Tecomaji and Rongui islands and seagrass beds in the area.

Seagrass recovery periods are predicted to be relatively rapid (months to years, according to Erftemeijer & Lewis, 2006). However, coral communities may take longer (years), particularly if massive corals are severely affected. Recovery time scales of decades may apply for lethal effects (Richmond, 2002).

These effects of increased turbidity on corals, seagrasses and associated communities within Palma Bay from capital dredging during the construction phase are predicted to extend to the local scale, and may be long term in duration for corals but short term for seagrasses. Impacts are likely to occur, and the impact intensity is expected to be medium. Impact magnitude during the construction phase is expected to be medium, and therefore effects on marine ecology are likely to be of MODERATE significance.

During the operational phase, maintenance dredging impacts will be restricted to onsite and will be of much lower intensity and magnitude (medium and low respectively). TSS is still likely to exceed the given thresholds, and therefore affect marine ecology, over the long term. Impact significance is thus predicted to be of MINOR significance.

The degree of confidence in this assessment is medium, as the predictions are based on simulation modelling and limited field data for dredge plume behaviour in these environments.

11.9.2 Mitigation Measures

The objective of the mitigation proposed below is to reduce the intensity and extent of the impacts from the initial capital and maintenance dredging effect in Palma Bay (ie the TSS concentrations within turbidity plumes and the areas affected).

Mitigation measures should be focused on the control of turbidity outside of the dredging footprint which is defined as the zone of high impact (ZHI), in which acute (lethal) levels of disturbance will occur, but within the boundary of the zone of moderate impact (ZOMI) (in accordance with the dredging guidelines for Western Australia (WA EPA, 2011)). Within the ZOMI, chronic (sub-lethal) effects may occur but eventual recovery of the affected communities is expected. The bounds of the ZOMI are set at 500m distance from the outer boundaries the dredge areas (ie the ZHI). An example is shown in *Figure 11.8* below where the marine facilities construction area has been considered as an amalgamated whole, ie the dredge areas are not treated individually with separate ZOMIs.

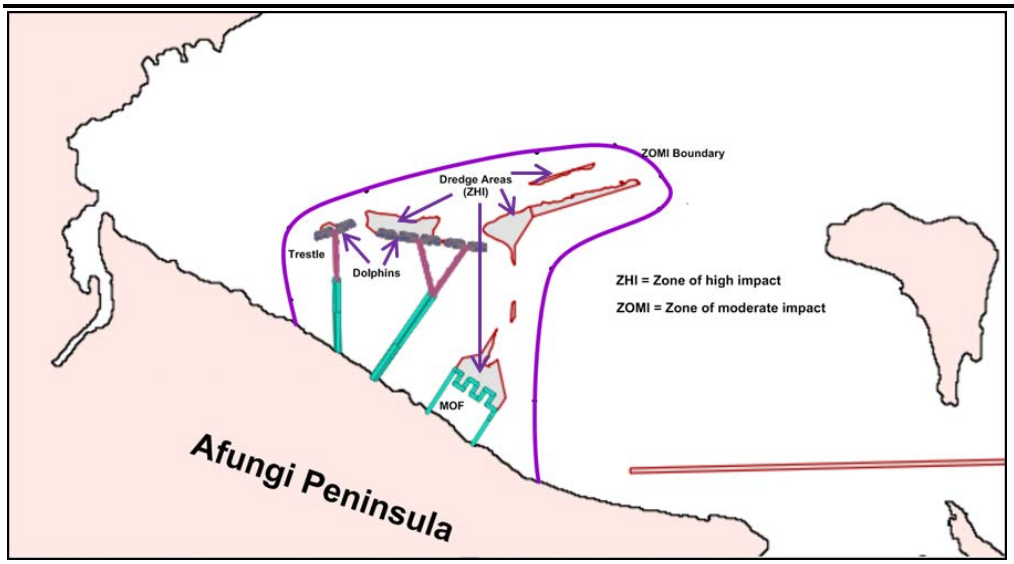
Within the ZOMI turbidity levels should not exceed 100mg/l TSS. In addition, turbidity levels in the ZMOI can exceed 10mg/l depending on the time durations during which exceedances occur. The 100mg/l and 10mg/l TSS values are broadly representative of the 1% and 25% surface light intensity (see *Figure 11.8*). Outside of the ZOMI, turbidity should be less than 10 mg/l and no more than 5mg/l above ambient levels. In this zone of influence turbidity plumes may occur, but should be transient and not generate adverse effects on coral or seagrass communities. Within the ZOMI the critical subsurface light thresholds at 5m depths are set at 25%, 10% and 1% of the surface light intensity, or their approximate TSS equivalents of 10mg/l, 30mg/l and 100mg/l.

During dredging, including reclaim management where applicable, as part of an adaptive management approach dredge plume intensity monitoring should be conducted on a near real time basis at locations within the outer boundary of the ZOMI. In a layout such as the example in *Box 11.1* suitable monitoring locations would be near to the outer eastern, northern and western boundaries where water depths exceed 5m. Note that a reference station will also be needed nearby but outside of the ZOMI to track ambient turbidity levels during dredging.

An example of the required responses to exceedances of the specified thresholds is outlined below:

- Turbidity levels are >10mg/l TSS equivalent – No action as this is expected for the ZOMI;
- turbidity levels approach 30mg/l TSS equivalent – If the threshold is exceeded for 40 days in a rolling 60 day period then determine causes and moderate dredging rate or move dredging activity to reduce turbidity levels. If the threshold is exceeded 50 days in a rolling 60 day period (ie 10 exceedances where exceedance 1 = 40 day period, 2 = 41 days, 3 = 42 days etc) stop dredging until dredging is shown not to be the cause at an acceptable level of certainty. In this case resume dredging. If dredging is the cause then modify dredging practice to reduce turbidity generation; and
- turbidity levels are >100mg/l TSS equivalent – If this threshold is exceeded for 40 days in a rolling 60 day period modify dredging practice to allow turbidity levels to dissipate. Monitor turbidity levels created during dredging activities to ensure turbidity levels of 10mg/l are not exceeded more than 500m from the dredging sites.

Box 11.1 ***Schematic Representation of the Marine Facilities Construction and Dredge areas in Palma Bay with a Demarcated Zone of Moderate Impact Outer Boundary (purple)***



Source: Lwandle, 2013. Approximately to scale.

11.9.3 Residual Impact

During the construction phase, impacts from capital dredging are restricted to within the ZOMI. Nested within this zone is the ZHI where the duration of effects will be permanent and of high intensity as the affected areas will be physically modified by the excavations associated with dredging. The limitation of lethal effects is restricted to within this zone and an expected medium term (<7 years) recovery of coral and seagrass communities within the larger zone of moderate impact will reduce the impact significance rating to MINOR.

Increased turbidity associated with maintenance dredging during the operational phase will be constrained in terms of discharge TSS concentrations and underwater light levels. The residual impact from this activity will be of a low intensity with a low magnitude. The effect of increased turbidity in the water quality on corals, seagrasses and associated biological communities is rated to be of MINOR significance.

The degree of confidence in this assessment is medium, as the predictions are based on simulation modelling and limited field data for dredge plume behaviour in these environments.

Table 11.8 Impacts of Dredging-induced Turbidity on Near Shore Marine Environment (Palma Bay Seagrass, Coral Reef and Associated Biological Communities)

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase (Capital Dredging)		
Duration	Long term	Long term
Extent	Local	Onsite
Intensity	Medium	Medium
Magnitude	Medium	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MODERATE**	**MINOR**
Operational Phase(Maintenance Dredging)		
Duration	Long term	Long term
Extent	Onsite	Onsite
Intensity	Medium	Low
Magnitude	**Low**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MINOR**	**MINOR**

11.10 IMPACTS OF TURBIDITY GENERATED FROM THE CUTTING OF A TRENCH THROUGH CORAL REEF AND ROCK ON NEAR SHORE MARINE ECOLOGY

11.10.1 Impact Assessment

The offshore sections of the gas import pipeline corridor pass over coral basement rock and associated reef. Different options to bring the pipelines into the bay are being considered and the final configuration and method will be finalised during the FEED. However, as described in *Chapters 4* and *5,* the cutting of a trench through the coral reef and rock is proposed as part of the Project's base case. The trench to house the pipelines is created with a CS Dredger with the cutter head physically grinding through the reef structure. There is uncertainty on how the coral rock in the gas import pipeline dredging will respond to this. Some international experience, for example PIANC (2010), indicates that this process may generate very fine particles and a large and persistent turbidity plume, as shown in *Figure 11.13*. Local (Saldanha Bay, South Africa) experience with CS dredging in areas with calcrete shows that the turbidity plumes may become highly concentrated and dense, and cover extensive areas of the seabed.

Figure 11.13 Example of a Turbidity Plume Generated by a Cutter Suction Dredger Dredging Coral Structures

Source: PIANC, 2010.

In a coral reef environment, these dense plumes may be trapped in gullies and crevices and exert deleterious effects on reef structure and associated organisms. If this occurs, the effects will be at a local scale, although long term to permanent and of high intensity. The magnitude of the impact would be high and, as effects on marine ecology will be likely, the impact significance will be MAJOR.

The level of confidence in this assessment is low, as data on rock properties or CS dredging in northern Mozambique near shore environments are not available.

11.10.2 Mitigation Measures

The objective of the mitigation proposed is to avoid creating the intense turbidity plumes that have been observed to be generated by CS Dredgers operating in coral environments.

Prior to the commencement of dredging coral reef and coral basement formations between Tecomaji and Rongui islands, undertake a pilot test of the selected dredge technique to check whether the action of the chosen dredging technique, eg CS Dredger head, on the coral basement and corals in the pipeline corridor is likely to generate plumes of very fine material.

- If such plumes occur dredging contractor is to implement measures to constrain the dispersion of such fines from the dredge area during the dredging operations. This can be done by controlling dredging rate or

modifying the dredging schedules or other techniques that the dredging contractor may have at his disposal.

- If pilot test shows plumes of material occur, monitor turbidity levels created during dredging activities as per the procedures described in *Section 11.9.2.*

These measures will be included in separate plans developed for construction and maintenance dredging that will be developed by the Project.

11.10.3 Residual Impact

Impacts are restricted to the onsite scale where the duration of effects will be permanent and of high intensity due to physical modifications associated with dredging. Lethal effects will be limited to the ZHI within the onsite scale. Because medium term (<7 years) recovery of coral and seagrass communities is expected within the larger ZOMI, a residual impact significance rating of MINOR is anticipated for the ZOMI.

Table 11.9 Impacts of Turbidity Generated from the Cutting of a Trench through Coral Reef and Rock on Near Shore Marine Ecology

	Without Mitigation	**Residual Impact (with Mitigation)**
Construction Phase		
Duration	Long term to permanent	Long term
Extent	Local	Onsite
Intensity	High	Medium
Magnitude	**High**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MAJOR**	**MINOR**

11.11 IMPACT OF INUNDATION OF SEABED AND BENTHOS BY DEPOSITING FINE SEDIMENTS FROM DREDGING ACTIVITIES ON NEAR SHORE MARINE ECOLOGY

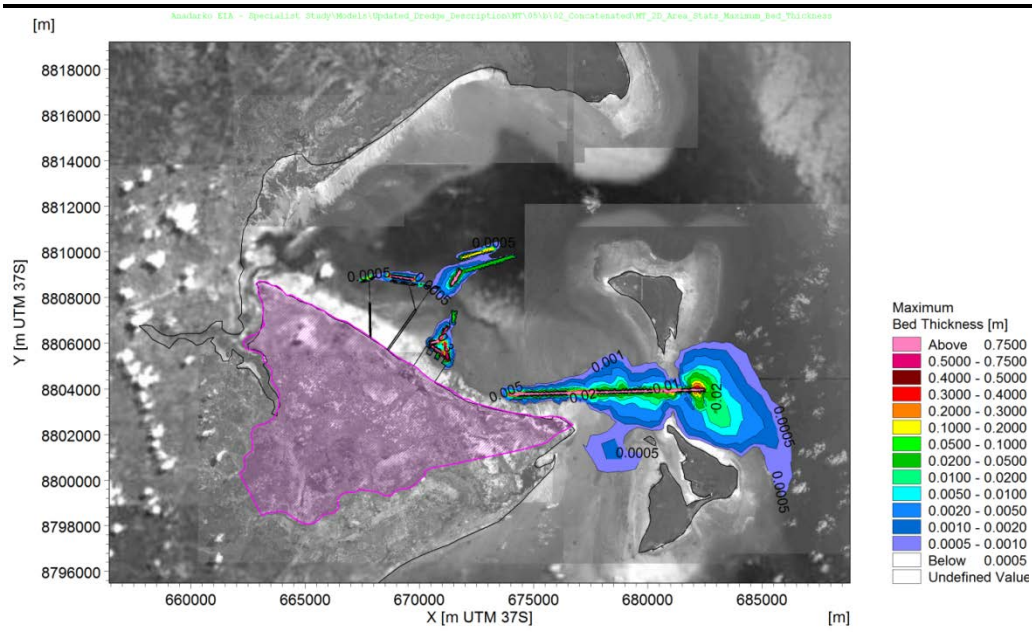
11.11.1 Impact Assessment

The sediments suspended by dredging in Palma Bay and those reintroduced to the marine environments by dewatering outflows from reclaims will sink out of the water column and deposit on the seafloor. The location of the deposition depends on the balance between bottom shear stress and resuspension requirements in terms of turbulence of the suspended sediments. Depositing sediments can inundate seagrass beds and bury corals or cover them with a veneer of sediment. This can cause coral mortality, especially in small-sized colonies, susceptible species and size classes, while the latter can generate sub-lethal effects such as reduced photosynthetic efficiency, changes in polyp activity and mucus production to remove sediment (PIANC, 2010). Effects on seagrass can include reduced photosynthesis due to the covering of leaf chloroplasts. The sub-lethal and lethal effects of burial vary with the period of burial.

Sedimentation thresholds for coral range from 10 to 300mg/cm²/day (PIANC, 2010). Following Doorn-Groen (2007), a conservative threshold of absolute burial depth of 7mm is used in this assessment. Data in Erftemeijer and Lewis (2006) indicate that *Thallasia*, *Thalassodendron*, *Halophila*, *Syringodium* and *Enhalus* (all genera recorded in Palma Bay) can withstand burial depths of 4cm, which is accepted as the conservative threshold for seagrasses in Palma Bay.

The distribution of sedimentation associated with the dredging activities required for the marine facilities and gas import pipeline corridor has been modelled by PRDW (2012). Predicted maximum deposition thicknesses for the 12-month modelled period (2008/2009) are shown in *Figure 11.14*. It is estimated that the respective thresholds will be exceeded in the dredging locations along the pipeline corridor; however, the exceeding of thresholds will be limited to these areas. Seagrass and coral adjacent to the corridor may be affected by increased levels of sedimentation.

Figure 11.14 Predicted Maximum Inundation Depth Distributions from Dredging in Palma Bay over a 12-month Period



Source: PRDW, 2012.

The deposition of fine sediments generated by capital dredging in Palma Bay causes a high intensity impact (sub-lethal and lethal effects) at the local scale in seagrass beds and coral reefs, with linked negative effects on associated organisms. The duration of the impact will be medium term as seagrass recovery periods are predicted to be relatively rapid – months for fast-growing small species such as *Halophila* and *Halodule,* to years for slower-growing larger forms such as *Thalassia* (Erftemeijer & Lewis, 2006). Coral communities may require years to decades (ie long term) to recover from lethal effects, particularly if massive corals are severely affected. The magnitude of the impact to both seagrass and coral is high during

construction and low during operations. As the impact is likely to occur during the construction phase, impact significance will be MAJOR.

Similarly, during the operational phase, the deposition of fine sediments generated by maintenance dredging will affect seagrass beds and coral reefs, but at the onsite scale and at a medium intensity. The impact significance is rated as MINOR.

The level of confidence in this assessment is medium, as the predictions are based on simulation modelling. However, there are no local available data on the effects of such impacts.

11.11.2 Mitigation Measures

The objective of mitigation is to reduce the intensity and extent of the effect, ie the amount of sediment depositing in the affected area. However, the resuspension of sediment at the CS Dredger head is an unavoidable effect. Selection of dredging equipment by the contractor will be appropriate to the depths and material types to be dredged and to minimise the creation of plumes. Dredging induced inundation and the biological responses to this specifically in corals must be determined.

11.11.3 Residual Impact

In the absence of practical mitigation measures, the significance of residual impacts will remain unchanged from those identified for the pre-mitigation scenario, both during construction and operations. To minimise the residual impact where possible, the Project is currently investigating the optimal solution during FEED.

Table 11.10 Impacts of Inundation of Seabed and Benthos by Depositing Fine Sediments from Dredging Activities on Near Shore Marine Ecology

	Without Mitigation	**Residual Impact (with Mitigation)**
Construction Phase (Capital Dredging)		
Duration	Medium term (seagrass) to long term (coral)	Medium term (seagrass) to long term (coral)
Extent	Local	Local
Intensity	High	High
Magnitude	**High**	**High**
Likelihood	**Likely**	**Likely**
Significance	**MAJOR**	**MAJOR**
Operational Phase (Maintenance Dredging)		
Duration	Medium term	Medium term
Extent	Onsite	Onsite
Intensity	Medium	Medium
Magnitude	**Low**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MINOR**	**MINOR**

11.12 IMPACT OF DREDGING REMOBILISED CONTAMINANTS ON NEAR SHORE MARINE ECOLOGY

11.12.1 Impact Assessment

Heavy metals and synthetic organic compounds held in the dredge area sediments may be remobilised to the water column through the agitation and turbulent mixing that dredging brings. The origins of such contaminants are, by definition, linked to human activity, mainly industries, agriculture and human settlements. None of these are developed to the extent where they may significantly influence water and sediment quality in the catchments of Palma Bay. This is evident by the sediment quality data listed in *Chapter 7* (eg Al, As, Ba, Be, etc) and the generally low dissolved inorganic nutrient concentrations measured in the bay and adjoining estuaries on Afungi Peninsula. The measured trace metal concentrations are well within the environmental quality targets listed for the West Indian Ocean Land Based (WIOLAB) region (UNEP & CSIR, 2009), and are also compliant with the sediment quality thresholds for the sea disposal of dredged sediments set by the 1996 Protocol to the London (Dumping) Convention (1). Accordingly, risks of pollution effects from remobilised contaminants due to dredging activities in Palma Bay are considered to be low.

Potential impacts to marine organisms will be short term during the construction phase and long term during the operational phase, as maintenance dredging will continue for the life of the Project. Due to the low concentrations of heavy metals and synthetic organic compounds within the target dredge area sediments of Palma Bay, the likelihood of harmful impacts to marine organisms is considered to be unlikely during capital and maintenance dredging (construction and operational phases respectively). The impact intensity is predicted to be negligible during both phases and, consequently, the significance of the impact is rated as NEGLIGIBLE.

The degree of confidence in the assessment is high, due to the current lack of development around Palma Bay and its catchment and the current sediment heavy metal concentrations for Palma Bay sediments.

11.12.2 Mitigation Measures

Given the apparent absence or very low presence of heavy metals and synthetic organic compounds within the native dredge area sediments, the significance of the potential impact is considered to be NEGLIGIBLE and mitigation is considered unnecessary.

(1) http://www.imo.org/ourwork/environment/pollutionprevention/pages/1996-protocol-to-the-convention-on-the-prevention-of-marine-pollution-by-dumping-of-wastes-and-other-matter,-1972.aspx

Table 11.11 Impact of Dredging Remobilised Contaminants on Near Shore Marine Ecology

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Short term	Short term
Extent	Local	Local
Intensity	Negligible	Negligible
Magnitude	**Negligible**	**Negligible**
Likelihood	**Unlikely**	**Unlikely**
Significance	**NEGLIGIBLE**	**NEGLIGIBLE**
Operational Phase (Maintenance Dredging)		
Duration	Long term	Long term
Extent	Onsite	Onsite
Intensity	Negligible	Negligible
Magnitude	**Negligible**	**Negligible**
Likelihood	**Unlikely**	**Unlikely**
Significance	**NEGLIGIBLE**	**NEGLIGIBLE**

11.12.3 Residual Impact

The impact significance to marine organisms from remobilised heavy metals and synthetic organic compounds into the water column as a result of dredging will remain NEGLIGIBLE during the construction and operational phases.

11.13 IMPACT OF DREDGING-INDUCED SEABED MODIFICATION ON NEAR SHORE MARINE ECOLOGY

11.13.1 Impact Assessment

Dredging for the approach channel to the Near Shore infrastructure and/or turning circles will remove or damage coral bommies on the western side of the channel (see *Figure 11.15*), affect approximately 16ha of seagrass meadows on the edge of the existing channels into the bay (see *Figure 11.15*), and alter the bathymetry of the southern portion of Palma Bay. In addition, dredging of the pipeline corridor will traverse approximately 7.6km of seagrass meadows, the coral bommie field west of Tecomaji and Rongui islands, the fringing coral reef between these islands and the deeper offshore soft coral community (see *Figure 11.15*). These modifications will have important consequences, including the loss of an estimated 152ha of seagrass area and habitats for coral biotopes. They will also directly and indirectly affect associated fish and invertebrate communities.

Impacts to the seagrass meadows and coral bommie field west of Tecomaji and Rongui islands will be permanent, as dredging of the approach channel and turning circle will continue during operations (ie maintenance dredging). Impacts to the fringing coral reef between these islands will be long term, as the corals are expected to begin recolonisation after the pipelines are laid.

Due to seabed modification by capital dredging activities in Palma Bay, seagrass and coral biotopes within the proposed dredge locations will definitely be damaged or destroyed (see *Figure 11.15*). The impact will be exerted at the local scale, and will have high intensity effects. The magnitude of the impact will be high, given the high biodiversity value of the damaged biotopes. Impact significance is expected to be MAJOR.

The degree of confidence in the assessment is high as damage will occur, habitats will be modified and recovery is uncertain.

40°25'0"E
40°30'0"E
40°35'0"E
40°40'0"E
10°45'0"S
10°50'0"S
10°55'0"S

Cabo Delgado Peninsula
Palma Bay
Tecomaji Island
Afungi Peninsula
Rongui Island
Queramimbi Island
FR
5
10
50
100
A
B

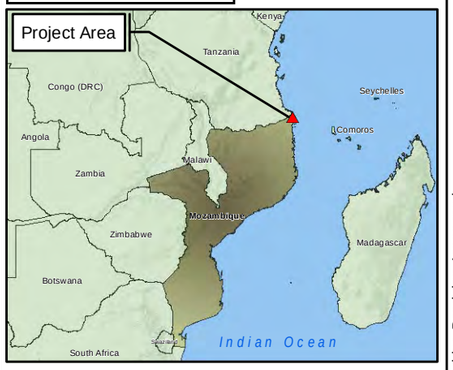
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

- Small Coral Bommie
- Larger (Porites) Coral Bommie
- Sand Crater with Coral
- Fringing Reef (FR)
- Seagrass Habitat
- Regional Roads
- Proposed Nearshore Infrastructure
- Proposed Pipeline Corridor Route
- Afungi Project Site

Bathymetry (Metres below Mean Sea Level)

- -5
- -10
- -50
- -100



MAIN MAP SCALE:

0 2 4 6
Kilometers

N

TITLE:

Figure 11.15:
Location of Pipeline Corridor, Dredging Areas and Sensitive Marine Biotopes

CLIENT:
Anadarko
Moçambique Área 1, Lda
eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 110 000

DRAWING: Location of Pipeline Corridor, Dredging Areas.mxd
REV: A

ERM
Great Westerford Building
240 Main Road
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Fax +27 21 686 073

Impacto Projectos e Estudos Ambientais
ERM

Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation. Lwandle Technologies, 2012. Inset Map: Esri Data

SIZE: A3

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11.13.2 Mitigation Measures

Seabed modification for the navigation channels and turning circles cannot be mitigated without compromising navigation safety for Project vessels using the Near Shore infrastructure. There is, however, some scope for mitigating impacts in the pipeline corridor. The objective of the mitigation measures outlined below is to reduce the extent of the effect of dredging-induced seabed modifications on marine biotopes and organisms, and to enhance at least partial recovery of some of the affected biological communities.

Mitigation measures to minimise impacts in the pipeline corridor include the following.

- Align the pipeline trench as far south as possible in the proposed corridor between Tecomaji and Rongui islands, within the constraints of engineering and construction feasibility. This will significantly limit the damage to the fringing reef between the islands of Tecomaji and Rongui, where the extent of fringing reef is much reduced in the area closer to the northern tip of Rongui Island.

- Reduce the width of the pipeline corridor to as low as practically possible, targeting approximately 100m, and employ a trenching procedure that avoids the requirement for a CS dredge (see *Section 11.9.2*).

- Enhance the recolonisation and regrowth of seagrass by providing suitable substrate such as shell grit for the attachment of germinating seagrass, or similar procedures where practical.

- Align the pipeline to avoid as much impact to the coral bommies to the extent practical. It is assumed that any coral bommies impacted would die or be seriously disturbed by the pipeline trenching process. Where bommies are impacted place either concrete blocks or quarried stone in 'clumps' in the disturbed area. The blocks or rocks will provide substrates for colonisation by corals and allow some level of recovery of the associated communities (*Figure 11.16*) (1).

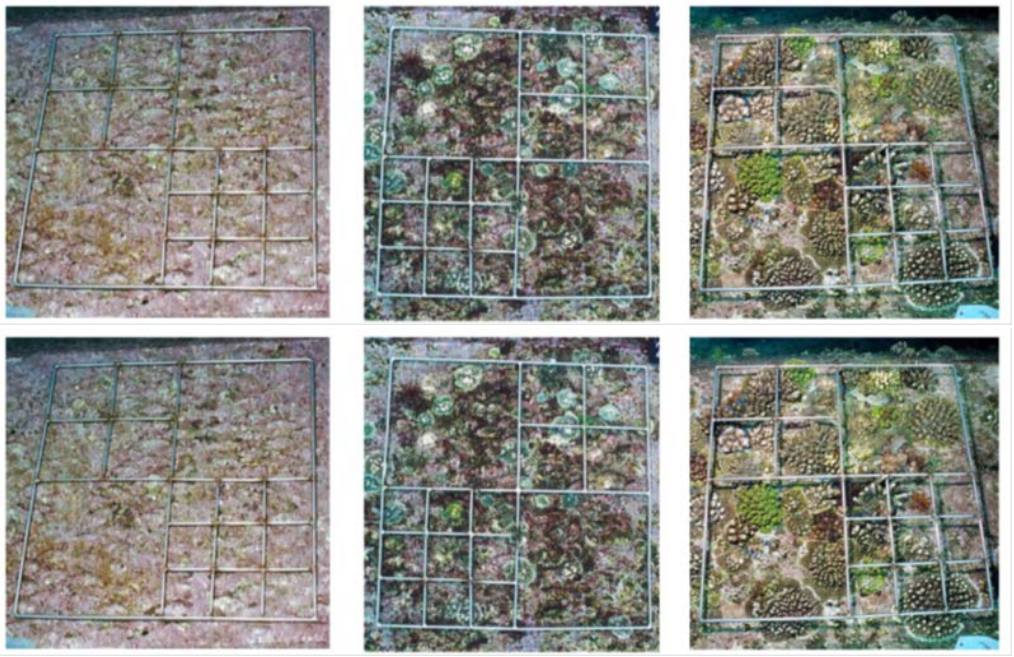
- Follow a similar approach as described above adjacent to the trenched area that goes through the fringing reef – and allow natural recolonisation to proceed (2) .

- Involve a coral taxonomist in detailed surveys along the gas import pipeline corridor prior to construction to determine the presence of *Acropora aspera* (3) and other coral species classified as endangered or rare in the IUCN Red List. Note that this is precautionary as, due to its role in

(1) This may be augmented by transplanting bommies but it is considered to be impractical to achieve this with a large number and size of the bommies that will be at risk.
(2) As opposed to attempting transplanting due to anticipated stronger wave and current forces.
(3) Categorised as 'Vulnerable' according to the IUCN Red List.

coral dispersal through the Western Indian Ocean, endemism within the East African Coral Coast ecoregion is low (Obura, 2012) and coral species are likely to be distributed throughout the ecoregion (Spalding *et al.,* 2007). As far is practical a representative collection of individual coral colonies present in the pipeline corridor, including IUCN Red List species, will be translocated away from area directly affected by construction.

Figure 11.16 Example of Coral Recolonisation of Concrete Eco-blocks at 2m Depth



Left: At installation. Centre: + two years. Right: + four years.

Source: PIANC, 2010.

11.13.3 Residual Impact

Seagrass and coral biotopes will be damaged or destroyed due to seabed modification by dredging in Palma Bay, but by implementing the above mitigation measures, the area of seagrass damaged will decrease from approximately 152ha to 46ha and the recolonisation rates will be enhanced, reducing the duration of the negative effect. The effects on coral bommies will be reduced by the narrower pipeline trench, and recolonisation enhanced by providing settlement substrate for coral larvae. The realignment of the pipeline trench closer to Rongui Island will significantly reduce the effects on the fringing reef between Tecomaji and Rongui islands.

Taking into consideration the above mitigation, impact duration is likely to be medium as the impact will extend beyond the construction phase (up to seven years). Impacts are likely to be local, and of medium intensity and low magnitude. As some seagrass and coral biotopes will be damaged or lost, the impact is definite. This, coupled with a low magnitude, will result in an impact of MINOR significance during the construction phase.

The degree of confidence for the assessment of the residual impact is medium, as there is no direct experience indicating that seagrass recolonisation will be successful in Palma Bay. Similarly, there are no monitoring data for East African coral recolonisation processes or recovery rates, so success rates are uncertain.

Table 11.12 Impact of Dredging Induced Seabed Modification on Near Shore Marine Ecology

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Long term (fringing reef) to permanent	Medium term
Extent	Local	Local
Intensity	High	Medium
Magnitude	**High**	**Low**
Likelihood	**Definite**	**Definite**
Significance	**MAJOR**	**MINOR**
Operational Phase: N/A		

11.14 IMPACT OF DISPOSAL OF DREDGE MATERIAL AT THE HEAD OF CANYON ON NEAR SHORE MARINE ECOLOGY

11.14.1 Impact Assessment

Dredge material will be pumped as a slurry to the head of the Afungi Canyon, where it will be discharged at the seafloor. The discharge pipe will be regularly relocated in the dredge material placement area to avoid accumulations of sediment, which may slump and generate possibly erosive turbidity flows down the continental slope located close offshore of the placement area. The designated material placement area is approximately 1km^2 in extent and is shown in *Figure 11.11*. The discharged sediment will smother and possibly result in the death of benthos within the placement area. The estimated 4.1Mm^3 of sediment from capital dredging and potential volumes of maintenance (to be determined during FEED) dredge material to be discharged will not be instantaneously dumped within the site, but will be progressively added over time.

The impact will be generated at the local scale, is likely to occur, and will be of high intensity in the dredge material placement area. Sediment texture in the dredge material and dredge material placement areas are dominated by sand, with low proportions of gravel-sized sediments (mostly coral and shell debris) and mud, similar to the material to be dredged. The dredge material will therefore be suitable for recolonisation, which will be both from in-migration and larval settlement. Recovery periods are predicted to be one to three years (Newell et al., 1998) and the duration of impact is therefore predicted to be short term. The impact intensity is expected to be high and the impact magnitude is considered to be medium. The impact significance rating is MODERATE.

The level of confidence in this assessment is medium, as although there are abundant surveys showing the limited effects of dredge material disposal in open coast dynamic environments, there are no local data to support this.

11.14.2 Mitigation Measures

The objective of the mitigation measures outlined below is to limit the impact to within the boundaries of the dredge material placement area and to ensure that biological communities adjacent to the designated dredge placement area are not exposed to smothering effects.

- Monitor benthos communities adjacent to the placement area pre- and post-dredging including taxonomic, abundance and biomass distributions.

- Record the locations of dredge material disposal and avoid dredge material disposal beyond the designated dredge placement area. To be developed as part of the maintenance dredging plan.

11.14.3 Residual Impacts

Benthos within the dredge placement area are likely to suffer lethal effects from dredge material but will recover within one to three years after the cessation of dredging. Through the implementation of the above mitigation, these effects will be limited to the dredge placement area itself and the intensity and magnitude of the impact are reduced to medium and low respectively. The impact significance will reduce to MINOR.

Table 11.13 Impact of Disposal of Dredge Material at the Head of Canyon on Near Shore Marine Ecology

	Without Mitigation	**Residual Impact (with Mitigation)**
Construction Phase		
Duration	Short term	Short term
Extent	Local	Local
Intensity	High	Medium
Magnitude	**Medium**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MODERATE**	**MINOR**
Operational Phase: N/A		

11.15 IMPACT OF MODIFICATION TO SAND BEACHES GENERATED BY THE PRESENCE OF NEAR SHORE PROJECT INFRASTRUCTURE ON MARINE COMMUNITIES

11.15.1 Impact Assessment

The Near Shore Project infrastructure marine facilities required for the proposed Project comprise a temporary Pioneer Dock, a MPD for heavy and/or large items, berths for loading LNG Carriers with product and LNG Export Jetties and trestles/causeways connecting these to land. Navigation marker buoys and possibly leading lights will also need to be established. The

creation and actual presence of these facilities will generate impacts on the physical coastal processes, the biological communities and marine ecological processes.

The extensive intertidal sand beaches on the northern shore of Afungi Peninsula are varied and biologically productive, as they support seagrass meadows and an array of benthic organisms (see *Chapter 7*). These beaches provide resources to artisanal fishers and forage for coastal birds, eg crab plovers, plovers, sandpipers, egrets, herons, hamerkop, etc. Autotrophs on the beaches include blue-green algae, algal mats, benthic diatoms and seagrass. The beaches receive particulate organic matter (POM) from the offshore seagrass beds, as indicated by seagrass wrack on the tide lines, and small estuaries that drain Afungi Peninsula. The overall POM supply sustains filter feeders such as bloodworm and mussels, and the predator community, including whelks, birds, etc.

The installation of the causeways and port structures will interrupt and cut off the longshore transport of sediment, resulting in changes in sedimentation patterns as well as longshore exchanges of POM across the intertidal area. It is expected that a change in sedimentation patterns will include increased accretion on the up-drift side of the infrastructure and the erosion of beaches on the down-drift side (PRDW, 2012). It will change the beach structure through the creation of pocket beaches, possibly affecting biogeochemical attributes and the intertidal and shallow subtidal biological community, in particular a loss of species dependent on high POM exchange. This effect may extend higher up the food chain to foraging birds using the intertidal area.

The installation of causeways and port structures across the intertidal beaches and extending into the shallow subtidal zone will permanently modify the beach structure and dependent ecological processes at a high intensity through the interruption of longshore sea water and POM exchanges. Impacts will begin during the construction phase and extend throughout the lifetime of the Project. This effect will be generated at an onsite scale, and impacts will be of a medium magnitude. The likelihood of the impact occurring is definite. The significance of the impact is predicted to be MODERATE for both construction and operational phases.

The degree of confidence for the assessment is medium, as although the broad properties and characteristics of the affected beaches are known, the dependencies on sea water and POM fluxes are not fully understood. The presence of H_2S in lower intertidal sediments implies surplus organic matter supply; therefore, the intertidal beach macrofauna, at least, may not be heavily influenced by these changes.

11.15.2 Mitigation Measures

The objective of the mitigation measures below is to ensure that some longshore sediment and water exchange is maintained to prevent the isolation

of the pocket beaches and facilitate POM supply, reducing the intensity of the impact. Mitigation measures include:

- placement of bridging/culverts within the causeways to ensure some water/particulate matter exchanges; and

- development of an active shoreline management and monitoring programme that includes:

    - a beach monitoring programme; and
    - use of land-based construction equipment to move sand from the areas of accretion to areas where erosion is evident.

11.15.3 Residual Impact

Longshore exchanges of sediment, sea water and POM are partially reduced by the change in design to the causeway structures, allowing a modified intertidal and shallow subtidal beach biological community to exist and sustain the dependent ecological processes. This will reduce the intensity of the impact to medium during both the construction and operational phases. Impact magnitude of the residual effect will be low and, given that the changes to the beach structure will definitely occur, the impact significance is expected to be MINOR. In addition, the suggested mitigation measures will help to reduce the erosion of beaches on the down-drift side of the Near Shore Project infrastructure.

Table 11.14 Impact of Modification to Afungi Peninsula Sand Beaches by Installation of Causeways and Port Structures on Marine Communities

	Without Mitigation	**Residual Impact (with Mitigation)**
Construction Phase		
Duration	Permanent	Permanent
Extent	Onsite	Onsite
Intensity	High	Medium
Magnitude	**Medium**	**Low**
Likelihood	**Definite**	**Definite**
Significance	**MODERATE**	**MINOR**
Operational Phase		
Duration	Permanent	Permanent
Extent	Onsite	Onsite
Intensity	High	Medium
Magnitude	**Medium**	**Low**
Likelihood	**Definite**	**Definite**
Significance	**MODERATE**	**MINOR**

11.16 IMPACT OF CONSTRUCTION OF ARTIFICIAL HARD STRUCTURES ON NEAR SHORE MARINE ECOLOGY

11.16.1 Impact Assessment

The LNG Export Jetties and various port structures will introduce hard structures into what is predominantly a sediment environment. The presence of this infrastructure will result in a loss of parts of the productive sand beach and subtidal zones along the northern coast of Afungi Peninsula. The presence of the introduced infrastructure will allow the establishment of hard substrate communities, macroalgae, mussels, oysters, barnacles, crabs, etc in the lower intertidal zone, and corals, sponges and associated organisms in the subtidal zone. The colonised structures will add to the habitat and associated biodiversity in the region but will potentially diminish some of its productivity, as areas of seagrass meadow will be reduced.

The introduction of new structures to the region may also facilitate colonisation by alien and potentially invasive species released into Palma Bay, by increasing the abundance of 'virgin' hard substrate material not native to the area (the impact of potential aliens or invasives is assessed in *Section 11.18*).

The impacts to the marine biotopes and associated communities within the Palma Bay will be similar for the construction and operational phases. The establishment of hard structures will potentially diminish productivity and change the biological communities in the bay at an onsite scale. The impact intensity will be medium, in that the altered environment will continue to function, but in a modified way. The impact is definite and will be long term to permanent. Impacts for both the construction and operational phases are considered to be of MODERATE significance.

The degree of confidence in this assessment is medium, as there are no monitoring data for East African coral colonisation processes or recovery rates, so success rates are uncertain.

11.16.2 Mitigation Measures

The objective of the mitigation measures outlined below are to (i) enhance biodiversity in at least the subtidal areas affected ; and (ii) to manage potential water quality impacts from corroding hard structures.

- Ensure that the protection employed for the footwall is suitable for colonisation by corals, sponges and associated organisms. This can be concrete, so-called eco-blocks (*Figure 11.16*), or large quarried stone, for example.

- Monitor and hard structures regularly for signs of excessive corrosion, undertake maintenance where required.

11.16.3 Residual Impact

The extent of seagrass areas lost will remain the same. However, with the introduced mitigation measures outlined above, the intensity is reduced to low to medium during both the construction and operational phases. Biodiversity in the affected areas is likely to increase and the resultant magnitude of the impact is reduced to low. Consequently, the residual impact significance is expected to be MINOR.

Table 11.15 Impact of Construction of Artificial Hard Structures on Near Shore Marine Ecology

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Permanent	Permanent
Extent	Onsite	Onsite
Intensity	Medium	Low to Medium
Magnitude	**Medium**	**Low**
Likelihood	**Definite**	**Definite**
Significance	**MODERATE**	**MINOR**
Operational Phase		
Duration	Permanent	Permanent
Extent	Onsite	Onsite
Intensity	Medium	Low to Medium
Magnitude	**Medium**	**Low**
Likelihood	**Definite**	**Definite**
Significance	**MODERATE**	**MINOR**

11.17 IMPACT OF PROJECT-GENERATED NOISE ON MARINE ORGANISMS IN THE NEAR SHORE

11.17.1 Impact Assessment

The major sources of noise in Palma Bay created by the Project are expected to be construction pile-driving and noise associated with shipping operations and dredging. Ship movements in the bay will introduce low-level noise pollution in the intensity range of 50-90dB re 1µPa @1m (1) (2). These noise levels approximate known thresholds of effects on marine organisms [53-85dB re 1µPa @1m (LGL, 2010)] and are therefore not assessed any further, as minimal effects can be predicted.

CS Dredgers produce broadband noise between 70Hz and 1kHz continuously at sound source levels of 160-180dB re 1 µPa @ 1m. Dredging occurs in shallow water, and reflection and absorption of sound energy occurs. Further, irregular seafloor features such as coral outcrops create sound shadows that

(1) Available at http://www.dosits.org/science/soundsinthesea/commonsounds/
(2) The source level of a specific sound source is often quoted as the (theoretical) sound level that would be measured at a distance of 1m from the source. It is standard to give source levels for underwater sound sources in units of dB re1µPa @1m.

complicate the calculation of safety radii as may be attempted from sound attenuation rates in deeper water. Predictions of safety radii for fish from sound distribution measurements in a North Sea application indicate that the Permanent Threshold Shift (PTS) would be limited to within 13m of a dredger, whereas Temporary Threshold Shift (TTS) could occur within 260m. If the sound thresholds for fish injury advocated by Popper et al. (2006) are applied, no effects are predicted, as the peak sound source level is less than the injury threshold. The effects of noise associated with dredging activities are thus not further assessed.

Percussion pile-driving will generate noise underwater with peak energy distributed in the 125 to 2,500Hz frequency (Elmer, 2007). Depending on pile diameters, the corresponding broadband sound peak to peak exposure levels range from 185 -198dB re 1µPa @1m at 750m distance (Matushek and Betke, 2009).

The organisms at risk from pile-driving noise levels in Palma Bay are marine mammals (whales and dolphins) and fish. Invertebrates do not have air bladders and so are considered to be relatively impervious to underwater sound at these levels. The threshold peak impulse sound pressure for direct physical trauma in marine mammals and fish is generally considered to be 200dB (McCauley, 1994; Richardson et al., 1995) with the United States of America Marine Fisheries Service setting a conservative limit of 180dB re 1µPa rms (US NMFS, 2000) for cetaceans.

Underwater sound produced by piling operations can cause hearing impairment in whales and dolphins, and/or alter their behaviours. Hearing impairment can be either temporary or permanent, depending on the intensity and duration of exposure (IWC, 2004). Temporary impairment can be caused by exposure to narrowband sound for relatively short (hours) periods of time at received levels of 134-173 dB re 1 µPascal rms (1) when this is 80 to 90dB above the species-specific threshold. As stated, these thresholds vary between species, but a conservative estimate that should include most baleen whales (eg humpback) and dolphins is an increase of 40-80dB (IWC, 2004). Behavioural modification may be generated at 120dB and above (Southall et al., 2007). However, there is some evidence for habituation if a sound source is semi-continuous (eg pile-driving), with humpback, minke, gray and fin whales showing this behavioural trait (NRC, 2003).

Fish mortality appears to require very high sound intensity levels. Hastings (1990, in Turnpenny & Nedwell, 1994) found that lethal thresholds for fish began at 229dB re 1 µPa rms and transient stunning was reported at 192 to 198 dB received, but that captive fish usually recovered after 30 minutes. Turnpenny and Nedwell (1994) noted that such transient stunning

(1) Broadband sound intensity data (dB re 1 µPa @ 1 m) are generally reported as peak to peak (p-p), zero to peak (0-p), root mean squared (rms) and/or sound exposure level (SEL). Safety radii are currently specified in rms units (US NMFS, 2000). The following approximate conversions apply for the same sound measured at the same location: 160 dB re 1 µPa @ 1 mrms = 170-1720-p, 176-178p-p and 145-150 dB re 1 Pa2.sSEL (from LGL, 2010).

could be lethal in the wild due to an increase in predation – but this, of course, requires that the predator is not similarly affected. Conversely, Santulli et al. (1999) reported no mortalities or overt pathological injury to caged European sea bass when exposed to received sound intensity levels above 200dB re 1 µPa rms.

Received impulsive sound can also cause sub-lethal pathological effects, including damage to hair cells in the hearing maculae, at received sound intensity levels of 150-193dB re 1µPa rms with no observed recovery (McCauley et al., 2003), and short-term biochemical responses but with unknown physiological effects at >200dB re 1µPa rms (Santulli et al., 1999). The most commonly observed responses to impulsive sound are behavioural. This can be restricted to startle and alarm responses at 150-160dB re 1µPa rms (Pearson et al., 1992) and subtle changes in distribution after exposure to 12 days at a source sound intensity level of 222.6dB re 1µPap-p (Slotte et al., 2004).

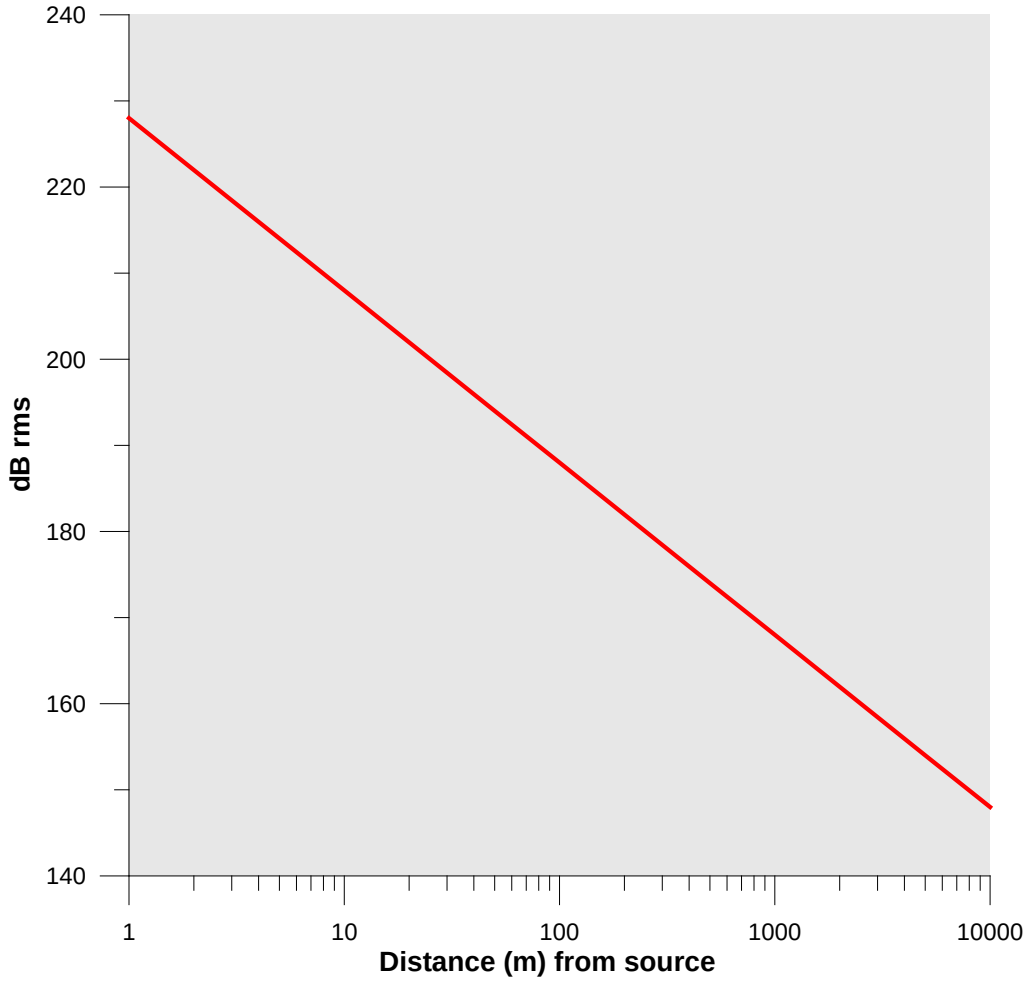
Critical underwater sound levels for whales and dolphins, therefore, are considered to be 180 dB re 1 µPascal rms for pathological injury and 120 dB re 1 µPa rms for temporary hearing impairment and behaviour, while that for fish is 150 dB re 1 µPascal rms for pathological injury and behaviour modification (1). Effect levels on turtles are not well defined, but it is assumed that these are similar to whales and dolphins (based on CSA, 2008).

The red line in *Figure 11.17* shows the sound attenuation curve for percussion piling with source sound levels back-calculated from the Matushek and Betke (2009) measurements. This indicates that whales/dolphins within 100m of the sound source (ie percussion piling) may suffer pathological injury and those within 80km may modify their behaviour, while fish within 600m may suffer permanent hearing impairment from percussion piling.

The sound energy attenuation plots in *Figure 11.17* are in agreement with sound attenuation patterns derived from acoustic modelling for seismic surveys in water depth of 25m south of Rongui Island (*Figure 11.18*). These show similar ranges to those calculated in *Figure 11.17*, although the distributions are elliptical as opposed to uniformly circular.

(1) This is quite conservative, as Popper et al. (2006) argues that levels of 190dB re 1 µPascal2.sec SEL are more appropriate for pile-driving generated sounds.

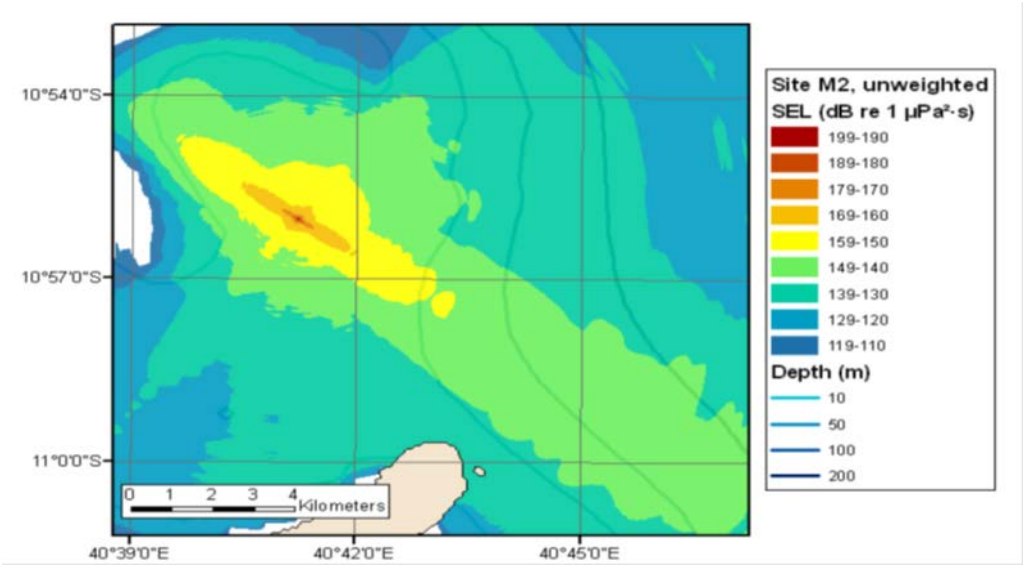
Figure 11.17 Sound Attenuation for Percussion Pile-driving with Distance Estimated, from Madsen et al. (2006)



Key:
The red line represents attenuation for percussion.

Source: Lwandle, 2012 based on Madsen et al., 2006.

Figure 11.18 Modelled Sound Field Map for Seismic Surveys in 25m Depth South of Rongui Island



Source: CSA, 2008.

It is apparent from *Figure 11.17* that the TTS effects on whales, dolphins and turtles will be only exceeded very close to the sound source, ie at the onsite extent within Palma Bay. Behavioural modifications could extend to the regional scale. Fish may experience some behavioural disturbance and non-lethal injury within 600m of the sound source, or at the onsite extent. This will endure for the short term during the construction phase only, and is rated to be of medium intensity and magnitude. Impacts to fish present are likely to occur during pile-driving. Dolphins, whales and turtles are expected to move away from unhealthy noise levels, and impact significance is predicted to be MODERATE.

The degree of confidence in the assessment is medium, specifically for the possible effects on whales, dolphins and turtles –they have to be within a close range of the generated sound to experience behavioural responses.

11.17.2 Mitigation Measures

The objective of the mitigation measure outlined below is to avoid the undue disturbance of megafauna (whales, dolphins and turtles) in particular, when in close proximity (<600m) of the piling site within Palma Bay.

- Where feasible, the MMOP should allow for a 'soft start' procedure when megafauna are present in the bay, for approximately 20 minutes prior to operating at the full cycle rate for percussion piling.

This will provide the opportunity for megafauna in particular to move out of the range of disturbance. As pointed out above, it is assumed that whales, dolphins and turtles will generally vacate areas where sound levels are uncomfortably high.

11.17.3 Residual Impact

The behavioural disturbance of and/or injury to whales, dolphins and turtles may be exerted at the local scale, but with a low likelihood of occurrence. The intensity and effective magnitude ratings will be reduced to low and the significance rating to NEGLIGIBLE should a 'soft start' procedure be implemented prior to percussion piling when megafauna are present in the bay.

Table 11.16 Impact of Noise on Marine Organisms in the Near Shore

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Short term	Short term
Extent	Regional (behaviour)/onsite (injury)	Local
Intensity	Medium	Low
Magnitude	**Medium**	**Low**
Likelihood	**Likely**	**Unlikely**
Significance	**MODERATE**	**NEGLIGIBLE**
Operational Phase: N/A		

11.18 IMPACT OF BALLAST WATER DISCHARGES FROM LNG CARRIERS AND THE INTRODUCTION OF ALIEN SPECIES ON NEAR SHORE MARINE ECOLOGY

11.18.1 Impact Assessment

During the operational phase, LNG Carriers will enter Palma Bay under ballast and will then discharge this while being loaded with LNG at the export berths. Ballast water discharges bring the risk of releasing organisms (including non-indigenous) entrained in source ports into the receiving port environment ie Palma Bay. In addition, the introduction or spreading of non-indigenous species through hull fouling of (typically slow-moving) vessels such as dredgers or Project equipment can occur, when fragments of organisms that reproduce vegetatively are transported to a receiving port and become established.

Carlton and Geller (1993) recorded >350 taxa in Japanese ballast water samples taken from vessels in Oregon, USA. Most of these taxa were holo- and meroplanktonic forms, but all of the major marine taxa were represented. This case shows that it is possible to transport entire plankton species assemblages across oceans. Further, Hutchings (1992) has provided evidence that, when ballast water is drawn from heavily populated areas with inadequate waste water treatment systems, viral pathogens such as cholera (*Vibrio cholerae*) (1) and contaminants can also be translocated through ballast water exchanges.

(1) http://www.imo.org/Conventions.

Once released into ports, alien species can become invasive through the establishment of populations, and can disrupt ecological processes. Carlton and Geller (1993) record 45 'invasions' attributable to ballast water discharges in various coastal states around the world. The invasives include planktonic dinoflagellates and copepoda, nektonic Scyphozoa, Ctenophora, Mysidacea and fish, and benthos such as Annelid oligochaeta and polychaeta, Crustacean brachyura and Molluscan bivalves. The establishment of benthic species in particular is aided by the presence of uncolonised surfaces such as those associated with new berth developments.

Species introduced from ballast water discharges can also impact seagrass stands. In the northern Mediterranean, the introduced *Caulerpa racemosa* replaced the host seagrass species *Posidonia oceanica* over large areas (>100 km^2), completely altering the seagrass biotope and having implications on fisheries (Williams, 2007). Similarly, coral reefs can be affected through the introduction of marine organisms via ballast waters in a number of ways, including the alteration of reef structures by introduced coral species. For example, the Indo-Pacific *Tubastarea coccinea* introduced to the Caribbean Sea is affecting local coral reef species (Goldberg & Wilkinson, 2004).

In view of the globally recorded negative effects of alien species transfers, the International Maritime Organisation (IMO) considers these introductions to new environments via ships' ballast water or other vectors as one of the four greatest current threats to the world's oceans (Awad et al., 2004). To reduce these risks, the IMO has instituted ballast water management regulations (1), including requirements for open ocean ballast water exchanges and associated ballast water management record books. The implementation of open ocean ballast water exchanges has been shown to reduce plankton concentrations within ballast water holding tanks on container vessels by 90 percent (Ruiz & Smith, 2005). The process can be abetted by long transit voyages between loading ballast water at the LNG offloading ports (probably in the Far East) and ballast water discharge in Palma Bay, which reduces the viability of organisms held in entrained ballast water.

All LNG Carriers loading LNG in Palma Bay will comply with the IMO requirements for open ocean ballast water exchange and/or the IMO standard of not discharging ballast water into Palma Bay if it holds <10 organisms larger than 50µm per cubic metre volume (2). The discharge of ballast water that is treated to IMO standards could include low concentrations of eggs, larvae or adults of alien species that may become invasive and alter local and regional biological communities. If invasive alien species are transferred into the bay, the effects on biodiversity and marine ecology (including seagrasses and corals) may be severe and affect communities permanently, and potentially at a regional scale. Impacts will be of high intensity and magnitude, as the effects can reverberate throughout the food chain and

(1) See http://www.imo.org/ Conventions.
(2) See http://www.imo.org/ Conventions.

would be long term. The probability of this occurring is considered to be unlikely. The impact significance is rated as MODERATE.

Compliance with IMO guidelines on ballast water treatment has shown a large reduction in the viability of any organisms that may be discharged with ballast water, and therefore the degree of confidence in the assessment is high.

11.18.2 Mitigation Measures

The objective of the mitigation measures outlined below is to further reduce the probability of releasing alien species into Palma Bay via ballast water discharges with time. These should be considered in a Ballast Water Management Plan.

- All ships entering Palma Bay that are linked in any way to the Project are to comply with current IMO regulations concerning ballast water discharge and treatment and be early adopters of IMO sanctioned techniques and processes to further reduce the viability of organisms entrained in ballast water.

- All slow-moving craft such as barges, entering the area from non-East African ports, are to have hull inspections for 'hitch-hiking' sessile alien species, eg barnacles, mussels, sponges, etc. If these are found, then controls are to be instituted to reduce the associated risks of them escaping to the Palma Bay marine environment. This should include requirements for hull inspection certificates prior to barge departures from their loading ports.

11.18.3 Residual Impact

The progressive adoption of developing ballast water control measures and processing techniques, as and when sanctioned by the IMO, will further reduce the likelihood of the release of non-indigenous organisms over time. However, due to the high magnitude of the effects that may arise should invasive species become established in northern Mozambique, the significance rating would remain as MODERATE, although the impact is unlikely to occur given the proposed mitigation during the construction and operational phases.

Compliance with the current IMO guidelines on ballast water treatment has shown a large reduction in the viability of any organisms that may be discharged with ballast water, and it is expected that new treatment methods accepted by that body will be more effective. The confidence in the mitigated scenario assessment is high.

Table 11.17 Impact of Ballast Water Discharges from LNG Carriers and the Introduction of Alien Species on Near Shore Marine Ecology

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Long term	Long term
Extent	Regional	Regional
Intensity	High	High
Magnitude	**High**	**High**
Likelihood	**Unlikely**	**Unlikely**
Significance	**MODERATE**	**MODERATE**
Operational Phase		
Duration	Long term	Long term
Extent	Regional	Regional
Intensity	High	High
Magnitude	**High**	**High**
Likelihood	**Unlikely**	**Unlikely**
Significance	**MODERATE**	**MODERATE**

11.19 IMPACT OF DISCHARGES FROM DESALINATION AND SEWAGE TREATMENT PLANTS ON NEAR SHORE WATER QUALITY AND MARINE ECOLOGY

11.19.1 Impact Assessment

The LNG Facility and its workforce will require potable water during the construction and operational phases. This will be acquired or supplemented by a reverse osmosis (RO) Desalination Plant. The planned workforce will also generate domestic sewage. The discharges from the Desalination and Sewage Treatment Plants will be combined and discharged into Palma Bay via the co-discharge outfall (1), and could pose environmental risks through the modification of sea water quality.

Desalination Plant effluents comprise brine and low concentrations of various chemicals used to prevent biofouling (typically sodium hypochlorite and biocides) and adjust pH (generally hydrochloric acid and sodium hydroxide). Additional chemicals typically used include sodium meta-bisulphite (a dechlorination agent), anti-scalants (generally organic acids) and coagulants (such as ferric chloride) (2). Brine at usually 60 to 70 PSU is continuously discharged, while water and system treatment chemicals may be discharged in batch mode to coincide with RO filter backwashing.

The main impacts on the receiving environment of desalination plants are from the brine itself, minor reductions in pH and possibly heavy metals scavenged from metal surfaces in the RO plant, such as nickel, chromium, molybdenum and iron (older plants may also have copper and lead in their effluents). This is to be processed to meet national and international

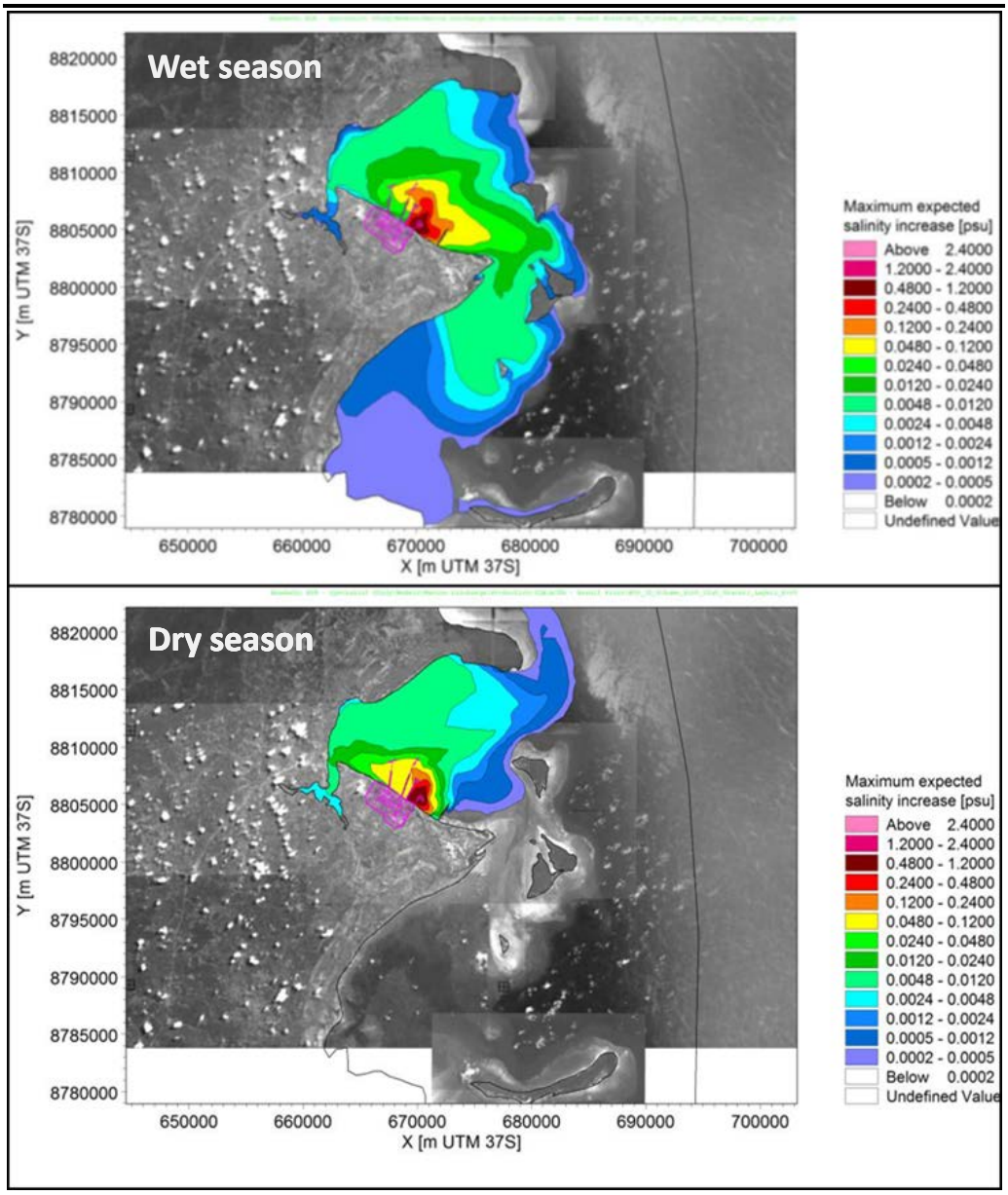
(1) The outfall for co-discharges will facilitate the discharge of treated sewage effluent, treated stormwater run-off from process areas, desalination plant brine and LNG Facility waste water. The impacts associated with stormwater and waste water on marine ecology are assessed in *Section 11.21*.
(2) http://www.pacinst.org/reports/desalination/desalination_report.pdf.

standards. The environmental risks represented by the brine are primarily the creation of a density interface between the brine and overlying water body, which limit oxygen and particulates exchanges between the seabed and water body, and salinity elevations that affect osmotic balances between marine organisms and their environment. Thresholds for the latter in terms of corals and seagrasses are 40 PSU (RPS, 2009). It is assumed that the brine water discharge configuration can optimise mixing with the receiving water body and therefore prevent density layering. Thresholds for co-discharges, considered to be primarily heavy metals, are those set as environmental quality targets (EQTs) for the WIOLAB region (UNEP & CSIR, 2009).

The discharge of treated domestic sewage is to comply with all the applicable standards, regulations (national and international) and/or approval or authorization . The highest risk to the marine environment is from eutrophication, especially due to increased levels of inorganic nitrogen. Eutrophication can promote phytoplankton growth, which affects light distribution, thereby compromising seagrasses and corals. In extreme cases, it can also affect oxygen distributions, impacting fish and other organisms. Threshold concentrations of inorganic nitrogen are 0.015 (corals) to 0.500mg/l (seagrasses). This implies that dilution factors of 20 to 670 need to be achieved at discharge to avoid compromising the EQTs. However, during the wet season, ambient dissolved nitrogen concentrations are 0.027mg/l *(Chapter 7),* implying that an upper dilution factor of 370 will be sufficient to avoid risks of any nutrient concentration increases above ambient levels in Palma Bay.

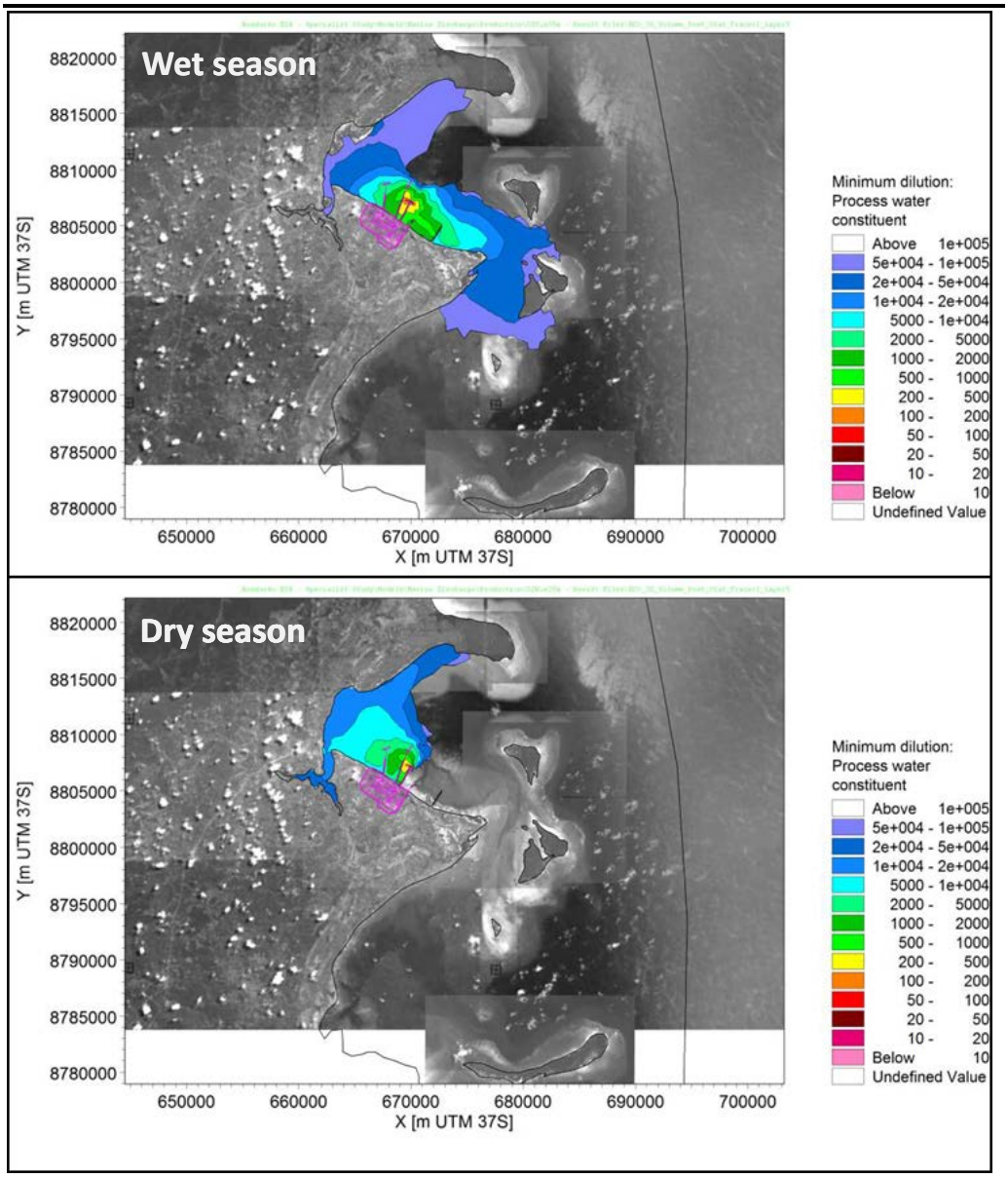
The behaviour of discharges from the proposed desalination plant and sewage treatment plants were modelled by PRDW (2012). *Figure 11.19* shows the predicted distribution for brine, and *Figure 11.20* depicts the predicted distribution for domestic effluent (as a conservative tracer, ie subject to dilution processes only and not being chemically or biologically transformed).

Figure 11.19 Maximum Increase in Salinity near the Seabed for the Brine Discharge during the Wet Season (Top) and Dry Season (Bottom)



Source: PRDW, 2012.

Figure 11.20 Minimum Dilutions in the Surface Layer for Treated Sewage Effluent (Process Water) during the Wet Season (Top) and Dry Season (Bottom)



Source: PRDW, 2012.

The predicted distributions indicate that the discharged brine will not exceed the specified receiving water quality threshold for coral and seagrass of 40 PSU (above), as the ambient salinities are approximately 35 PSU across most of Palma Bay (*Chapter 7*) and the maximum increase modelled is +2.4 PSU. Dilutions of sewage effluent are predicted to be high, and it is apparent that the set receiving water quality threshold will be exceeded in the immediate area of the discharge point only (200 to 500 dilution band in *Figure 11.20*).

Operational water discharges from the Desalination and domestic sewage treatment plants could compromise water quality in Palma Bay at the onsite scale over the life of the Project, but with negligible or undetectable short-term effects on marine ecology and/or marine ecological processes. The impact

magnitude is rated as negligible and, given that effects will be unlikely, impact significance is expected to be NEGLIGIBLE.

The degree of confidence in the assessment is high. The planned discharges have low discharge rates, and the PRDW (2012) model results are consistent with measurements and other modelling investigations for desalination and treated sewage treatment plant discharges.

11.19.2 Mitigation Measures

The objective of the mitigation measure outlined below is to restrict the intensity and extent of related impacts.

- Ensure that the Project's process water (eg brine and treated sewage effluent) for operational discharges into Palma Bay operate at optimum efficiency in line with the Projects Water Resources and Wastewater Management Plan, through auditable maintenance schedules, and meet all water quality-related effluent parameters.

- Treated sewage will comply with all the applicable standards, regulations (national and international) and/or approval or authorization.

Through the course of FEED, the optimal solution for treatment and disposal of effluents will be investigated.

11.19.3 Residual Impact

With the implementation of the mitigation outlined above, water quality effects of the discharges will be restricted to the immediate proximity of the release points, resulting in a reduced risk to corals and seagrasses within Palma Bay. Impact significance will remain NEGLIGIBLE.

Table 11.18 Impact of Desalination and Treated Sewage Discharges on Near Shore Water Quality and Marine Ecology

	Without Mitigation	**Residual Impact (with Mitigation)**
Construction Phase		
Duration	Short term	Short term
Extent	Onsite	Onsite
Intensity	Negligible	Negligible
Magnitude	**Negligible**	**Negligible**
Likelihood	**Unlikely**	**Unlikely**
Significance	**NEGLIGIBLE**	**NEGLIGIBLE**
Operational Phase		
Duration	Long term	Long term
Extent	Onsite	Onsite
Intensity	Negligible	Negligible
Magnitude	**Negligible**	**Negligible**
Likelihood	**Unlikely**	**Unlikely**
Significance	**NEGLIGIBLE**	**NEGLIGIBLE**

11.20 IMPACT OF THE DISCHARGE OF TREATED PRODUCED WATER INTO THE NEAR SHORE ON MARINE ECOLOGY

11.20.1 Impact Assessment

Produced water is water that was trapped along with the natural gas being extracted, within the sedimentary rock formations. Produced water is extracted from the wells along with the natural gas. The produced water will be treated to meet applicable standards (see below) and discharged into Palma Bay. Alternative discharge measures in the industry include discharge at the sea surface within the natural gas field or injecting the produced water and transmitting it back into the reservoirs from which it was drawn. However, these options are not available to the Project as there will be no surface platforms at the natural gas well sites.

Produced water has the potential to contain dispersed oil, hydrocarbons, polycyclic aromatic hydrocarbons, phenols, ketones and alcohols, along with zinc, lead, manganese, iron and barium and naturally occurring radioactive materials (NORM) (Veil et al., 2004). The volumes of produced water extracted depend on the rock strata hosting the natural gas as well as the characteristics of the well itself (horizontally vs vertically drilled) and the type of well completion, etc (Veil et al., 2004). The risks associated with produced water discharges include, toxicity effects on organisms in or passing through the discharge plume and tainting effects on shellfish and fish that are harvested for human consumption.

The estimated volumes of produced water that will be delivered to the LNG Facility are 1,600bbl/Train/day, which will subsequently be treated and discharged. When two Trains are operational, this will generate 3,200bbl/day, which is equivalent to 509m^3/day. At full production it is estimated that six Trains will run, and the corresponding produced water volume will be 9,600bbl/day or 1,526m^3/day. The available information about the natural gas field formation water quality is summarised in *Table 11.19*.

The mean salinity of the produced water is approximately 12ppt, although this varies considerably across the samples analysed, and ammonia and strontium concentrations are high. Comparisons with WIOLAB's EQTs (UNEP & CSIR, 2009), however, indicate that the produced water concentrations are compatible with these guidelines.

Table 11.19 Project's Produced Water Quality – from Samples Drawn from an Average Depth of 2,750m below the Seabed Compared to WIOLAB Environmental Quality Targets (EQTs)

Variable	Units	Means	Standard Deviation	Sample Size	WIOLAB EQT
pH		7.35	0.35	23	7-9
Salinity	ppt	12.45	26.85	26	15-36
Li	µg/l	1.99	0.97	23	
Na	µg/l	4077.54	1193.71	26	
NH_4	µg/l	33.71	8.00	20	600

Variable	Units	Means	Standard Deviation	Sample Size	WIOLAB EQT
K	µg/l	71.16	39.30	26	
Mg	µg/l	11.07	7.16	26	
Ca	µg/l	771.17	677.10	26	
Al	µg/l	0.07	0.05	14	
B	µg/l	118.54	55.53	26	
Ba	µg/l	5.02	2.91	26	
Cu	µg/l	0.05	0.04	9	1.3
Fe	µg/l	4.08	7.91	14	
Mn	µg/l	0.47	0.54	26	
P	µg/l	0.19	0.10	11	50
S	µg/l	35.63	31.86	26	
Si	µg/l	58.00	25.10	26	
Sr	µg/l	24.71	18.78	26	
Zn	µg/l	1.14	0.63	26	15

Source: Anadarko, 2012. WIOLAB EQTs from UNEP & CSIR, 2009.

Although heavy metal concentrations within produced water are typically low, hydrocarbons and phenols may be more variable. Such compounds have the potential to taint fish flesh (UNEP & CSIR, 2009). The organisms that may be affected are primarily those in the footprint of the discharge plume where dilutions are predicted to be relatively low (eg > than 500x as shown in *Figure 11.20*). Important taxa potentially affected include bivalve molluscs and fish, such as Siganidae, that forage on epiphytes on seagrass; both groups form part of the artisanal fishery in the region.

Flesh tainting can occur at low in water concentrations, eg 1 mg/l for phenol and 0.25 mg/l for benzene, toluene, ethylbenzene, and xylenes (BTEX) compounds (UNEP & CSIR, 2009). Despite the presence of such compounds in produced waters, OGP (2005) reports that detection of tainting effects in both wild and caged organisms exposed to produced water discharges is uncommon. Given that fishing activities within the area of effluent discharge are likely to be limited due to exclusion zones that will be imposed in the bay (see *Chapter 4*) and given that discharge plume dilution rates are predicted to be high (as detailed above), it is considered unlikely that tainting effects on organisms landed by the artisanal fishery or aquaculture industry will be measureable.

Treated produced water will be discharged into Palma Bay during the operational phase, adding to the potential load being delivered by process water and/or stormwater discharges. This could compromise water quality in Palma Bay at the onsite scale for the life of the Project (ie long term), but it is expected that this will have undetectable effects or negligible intensity on marine ecology and/or marine ecological processes. Impact magnitude is likely to be negligible and, thus, impact significance is predicted to be NEGLIGIBLE. It should be noted, however, that the optimum methods to address all Project discharges will be further investigated during FEED.

The degree of confidence in this assessment is medium, due to the limited water quality baseline available for formation water.

11.20.2 Mitigation Measures

Although not deemed necessary according to the significance rating allocated, it is suggested that the treated formation water be discharged along with the brine from the Desalination Plant at the LNG Export Jetty. The flow rate from the Desalination Plant discharge will be approximately 120l/sec. The estimated discharge rate for the formation water is approximately 18l/sec for six Trains, ie 15 percent of the Desalination Plant discharges. This will add a marginal benefit in brine dilution, due to the generally low salinity levels expected in the formation water (*Table 11.19*).

The objective of the mitigation measure outlined below is to achieve an environmentally safe discharge of treated formation water.

- In line with the Project's Water Resources and Wastewater Management Plan, combine the flow of the treated produced water with the co-discharge described in *Section 11.19*.

11.20.3 Residual Impact

The impact significance rating will remain NEGLIGIBLE.

Table 11.20 Impact of the Discharge of Treated Produced Water into the Near Shore on Marine Ecology

	Without Mitigation	**Residual Impact (with Mitigation)**
Construction Phase: N/A		
Operational Phase		
Duration	Long term	Long term
Extent	Onsite	Onsite
Intensity	Negligible	Negligible
Magnitude	**Negligible**	**Negligible**
Likelihood	**Likely**	**Likely**
Significance	**NEGLIGIBLE**	**NEGLIGIBLE**

11.21 THE IMPACT OF EPISODIC STORMWATER DISCHARGES FROM THE LNG FACILITY ON NEAR SHORE MARINE ECOLOGY

11.21.1 Impact Assessment

Run off from the LNG processing areas will be directed to one or more internal collection systems. This potentially contaminated stormwater will be drained to the stormwater retention basin and inspected. If deemed acceptable, the water will be discharged directly into Palma Bay. If deemed unacceptable for discharge, the stormwater will be treated onsite prior to discharge into Palma Bay. Therefore, contaminant loads in stormwater discharged through the outfall into Palma Bay will be low.

The stormwater retention basin allows for the removal (via settling out) of any suspended solids. It will be sized to a capacity sufficient to catch the 'first flush' of stormwater. This generally contains the highest contaminant loads.

Episodic stormwater discharges from the LNG Facility area during construction or operations could compromise water quality over the short term, at an onsite scale, within Palma Bay. Effects on marine ecology and/or marine ecological processes are likely to occur, but are predicted to be of negligible intensity and of low magnitude. This impact is likely to occur and, thus, the impact significance is MINOR during the construction and operational phases.

The degree of confidence in this assessment is high. The stormwater management system will be adequate for its purposes and is designed to accommodate a 100-year storm event. LNG facilities are not known to generate high contaminant loads, and the PRDW (2012) model results are consistent with measurements and other modelling investigations for stormwater discharge from process areas.

11.21.2 Mitigation Measures

The objective of the mitigation measure outlined below is to prevent contaminated stormwater from being discharged to Palma Bay.

- Establish a Water Resources and Wastewater Management Plan to GIIP for stormwater management.

- Establish a stormwater management system with stormwater retention dam(s) sufficient to capture the first flush of stormwater. Treat any stormwater that may be impacted (particularly by hydrocarbons) prior to disposal or discharge.

11.21.3 Residual Impact

The water quality effects of any stormwater discharges managed through the Project's stormwater system are unlikely. If they occur, however, effects would be restricted to modifications of the Near Shore surface salinity fields, with NEGLIGIBLE significant implications for the marine ecology of Palma Bay.

Table 11.21 Impact of Episodic Stormwater Discharges from the LNG Plant on Near Shore Marine Ecology

	Without Mitigation	**Residual Impact (with Mitigation)**
	Construction Phase	
Duration	Short term	Short term
Extent	Onsite	Onsite
Intensity	Negligible	Negligible
Magnitude	**Low**	**Low**
Likelihood	**Likely**	**Unlikely**

	Without Mitigation	Residual Impact (with Mitigation)
Significance	**MINOR**	**NEGLIGIBLE**
Operational Phase		
Duration	Short term	Short term
Extent	Onsite	Onsite
Intensity	Negligible	Negligible
Magnitude	**Low**	**Negligible**
Likelihood	**Likely**	**Unlikely**
Significance	**MINOR**	**NEGLIGIBLE**

11.22 IMPACT OF INFILLING AN ESTUARY ON NEAR SHORE MARINE ECOLOGY

11.22.1 Impact Assessment

The onshore LNG Facility footprint covers a small estuary with mangrove stands towards its eastern boundary (*Figure 11.21*). This estuary will be filled in, probably with sediment reclaimed during the dredging campaigns. The flows from the estuary catchment will be rerouted towards the east and drain into Palma Bay through an artificial mouth. The existing mangrove stand will be removed during this process.

The mangrove community in this estuary includes Avicennia, Sonneratia and Rhizophora spp. (*Figure 11.21*) in the estuary mouth area. This is similar to the estuary at Palma and the larger mangrove stands around the estuary on the eastern tip of Afungi Peninsula. It is assumed that the backshore flora is also similar to these larger systems, which will then include Bruguiera, Ceriops and Xylocarpus spp. Thus, although diverse in terms of mangroves, the stands that will be filled in are not unique in Palma Bay or the larger region (Richmond, 2002).

Figure 11.21 Avicennia (Foreground) and Rhizophora spp. (Background) Mangroves in the Estuary on the Eastern Boundary of the Proposed LNG Facility

Source: Lwandle, 2012.

Mangroves in estuaries are known to be highly productive and complement other biotopes, including seagrasses and coral reefs, in ecological function and biodiversity. The impacts on marine ecology resulting from the loss of the estuary and associated mangrove stand during the construction phase will be permanent, of medium intensity and at a local scale (Palma Bay). Owing to the smaller size of the mangrove stand compared with the others in the bay and wider area of the northern Cabo Delgado coastline, the magnitude is rated as medium. As this impact will definitely occur under the proposed Onshore Project Footprint, the significance is MODERATE.

The degree of confidence in this assessment is high. Even though the impacted mangrove stand is relatively small compared with others that exist in Palma Bay and beyond, the loss of the mangrove system is considered to be a medium biodiversity loss.

11.22.2 Mitigation Measures

The Onshore Project layout has been revised to avoid and minimise impacts to sensitive areas across the Afungi Project Site. However, the preservation of this particular mangrove stand is incompatible with the establishment of the LNG Facility on the designated site. The objective of the mitigation measures outlined below is to obtain some benefit from the area to be filled in by harvesting its resources.

- Infill from the top of the remaining estuary to the bay to allow motile organisms, such as fish and crabs, to escape to the downstream Palma Bay water body and shoreline.

11.22.3 Residual Impact

Resources such as wood should be harvested/extracted and optimal use made of the mangrove system prior to the infilling of the estuary. The impact ratings remain the same post-mitigation, including significance, which is rated as MODERATE, as the establishment of the LNG Facility will result in the loss of a multispecies mangrove stand on the LNG Processing Area's eastern boundary.

Table 11.22 Impact of Infilling and Estuary on Near Shore Marine Ecology

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Permanent	Permanent
Extent	Onsite and local	Onsite and local
Intensity	High (onsite)/Medium (local)	High (onsite)/Medium (local)
Magnitude	**Medium**	**Medium**
Likelihood	**Definite**	**Definite**
Significance	**MODERATE**	**MODERATE**
Operational Phase: N/A		

11.23 IMPACT OF SECURITY/EXCLUSION ZONES ON FISH DISTRIBUTIONS IN THE NEAR SHORE

11.23.1 Impact Assessment

The establishment of permanent and semi-permanent security or exclusion zones in the intertidal, shallow subtidal and deeper areas around the LNG Facility and the Near Shore infrastructure (Pioneer Dock, MPD and LNG Export Jetties) during the construction and operational phase will displace artisanal fishing effort in Palma Bay. It is noted that fishing and/or marine resource and/or estuary resource exploitation is likely to increase in the bay, due to the influx of people into the area. The displacement is predicted to increase fishing pressure outside of the security zones. Some measure of protection will be provided to the fish community within the zones. These comprise a minor proportion of the Palma Bay water surface area and will therefore not be significant. Intertidal beach areas within the security zones may become biologically richer, with possible benefits to foraging coastal seabirds. This, too, is uncertain, as the beaches themselves will have been modified to a large degree by the marine facilities.

The establishment of security zones around the LNG Facility and the Near Shore Project infrastructure will displace artisanal fishing efforts and locally increase exploitation pressure on the fish community outside of the zones over the long term. The intensity of the effects is likely to be medium at the local

scale. Impact magnitude is expected to be low magnitude in the wider context. Informal observations during field surveys indicate that fishing pressure is already high in Palma Bay and surrounds, with even fish classed as marine ornamentals (eg butterfly fish, banner fish, moorish idols, etc) being caught by trap and harpoon and presented for sale in the local fish market. The likelihood of the impact occurring is likely and, thus, impact significance is rated as MINOR.

The degree of confidence in this assessment is low, as the increased extent of fishing pressure is not known given that the fishing pressure is already high in Palma Bay.

11.23.2 Mitigation Measures

No mitigation measures are identified.

11.23.3 Residual Impact

The impact significance remains unchanged, as no mitigation measures have been identified.

Table 11.23 Impact of Security Zones on Fish Distribution in the Near Shore

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Long term	Long term
Extent	Local	Local
Intensity	Medium	Medium
Magnitude	**Low**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MINOR**	**MINOR**
Operational Phase		
Duration	Long term	Long term
Extent	Local	Local
Intensity	Medium	Medium
Magnitude	**Low**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MINOR**	**MINOR**

11.24 IMPACT OF SHIP OPERATIONAL DISCHARGES ON NEAR SHORE MARINE FAUNA AND SEABIRDS

11.24.1 Impact Assessment

This impact considers the effects on water quality and the health of marine fauna and seabirds within the bay of discharging sewage, deck drainage, bilge water and machinery space drainage, emissions to the atmosphere and galley and garbage waste originating from shipping operations into Palma Bay. The impacts could potentially arise from contractors operating support and other vessels that are not compliant with the provisions of MARPOL 73/78 or other relevant international and domestic instruments. Since LNG Carriers operate

under strict international standards, it can be assumed that they will adhere to IMO requirements, but the effectiveness of controls on other vessels is uncertain.

Directly or indirectly discharged solid and liquid wastes from marine vessels during any phase of the development could potentially result in a proliferation of litter and compromised water quality, which could harm marine organisms, seabirds and biodiversity in Palma Bay. If the maritime laws are obeyed, the potential pollution impacts of routine operational emissions, discharges and waste disposal at sea will typically be localised, of medium intensity, and short term in duration. Impacts to marine ecology are likely to occur should the discharges take place and would be of medium magnitude, thus resulting in impacts of MODERATE significance.

The degree of confidence in this assessment is medium, as the extent of control over and inspection of vessels to be undertaken by the Project and contractor vessels was not specified at the time of report compilation.

11.24.2 Mitigation Measures

The objective of the mitigation measures outlined below is to eliminate discharges into Palma Bay and provide adequate waste reception and disposal facilities.

- Prior to the establishment of the Port Reception Facilities in Palma Bay (ie during the construction phase) vessels associated with the EPC Contractor will comply with MARPOL 73/78 and utilise MARPOL compliant waste facilities elsewhere for offloading wastes.

- All Project vessels will comply with MARPOL 73/78. This will, among other things, necessitate the provision of Port Reception Facilities for vessels based at the facility (ie support vessels and tugs), as well as effective waste disposal.

11.24.3 Residual Impact

If the maritime laws are successfully enforced and adequately managed, and Port Reception and associated recycling or disposal facilities are provided, the potential pollution impacts of routine operational emissions and discharges will remain at a local scale, at a low intensity. Impacts will be short term in duration ie they may occur but would be of low magnitude. Impact significance is deemed to be NEGLIGIBLE through all phases of the Project.

Strict compliance with the requirements of MARPOL 73/78 would ensure that the degree of confidence in the mitigated scenario assessment is high.

Table 11.24 Impact of Ships Operational Discharges on Near Shore Marine Fauna and Seabirds

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Short term	Short term
Extent	Local	Local
Intensity	Medium	Low
Magnitude	**Medium**	**Low**
Likelihood	**Likely**	**Unlikely**
Significance	**MODERATE**	**NEGLIGIBLE**
Operational Phase		
Duration	Long term	Long term
Extent	Local	Local
Intensity	Medium	Low
Magnitude	**Medium**	**Low**
Likelihood	**Likely**	**Unlikely**
Significance	**MODERATE**	**NEGLIGIBLE**

Chapter 12

Onshore Environmental Impact Assessment and Mitigation

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12.1 INTRODUCTION

This chapter assesses potential biophysical impacts in the Onshore environment. These impacts have been identified based on primary research (fieldwork and data gathering), secondary data (information from previous studies in the area) and professional judgement based on experience.

Key impacts and associated mitigation measures are listed below and described in *Sections 12.2* to *12.13*:

- Physical impacts to:
  - air quality;
  - GHG emissions;
  - noise;
  - landscape, seascape and visual;
  - soils;
  - hydrology; and
  - groundwater.

- Biological impacts to:
  - surface water ecology;
  - vegetation;
  - herpetofauna (reptiles and amphibians);
  - avifauna (birds); and
  - mammals.

12.2 AIR QUALITY

12.2.1 Overview

The potential for impacts to air quality due to emissions arising from the Project are assessed by comparing the predicted impacts against standards and guidelines for the protection of human health and critical levels for the protection of sensitive ecology. The assessment uses dispersion modelling to predict the ground level increases in air emission concentrations attributable to the Project emissions, to establish the potential for significant impacts to occur.

Potential impacts to human health are assessed by comparison to IFC Guidelines (1) and Mozambique and international air quality standards, while potential impacts on sensitive habitats are assessed through comparison with

(1) International Finance Corporation (2007) Environmental, Health, and Safety (EHS) Guidelines General EHS Guidelines,

relevant critical levels. The USEPA AERMOD atmospheric dispersion model was used to evaluate the potential impacts from the emissions arising from the operation of the LNG Facility. Scenarios for the initial operation of two LNG Trains and for the future operation of six LNG Trains were modelled. These scenarios and the sources considered are discussed in *Section 12.2.3*.

An initial review of the Project identified that impacts associated with road traffic during construction or operation are unlikely to be significant, due to the relatively small number of vehicles expected to be operated (equipment and machinery will be transported to the site by sea) and the low emission concentrations in the receiving environment. On this basis, traffic has not been assessed.

The Project will also include the provision of waste incineration facilities. However, the expected emissions from the incineration of waste (approximately 2,200t/ year) were deemed insignificant with regards to the dispersion modelling results during the construction phase and less during the operational phase). Considering that the incinerator operation is compliant with IFC Guidelines, the emissions from waste incineration are minimum and will not be further discussed in this assessment.

Types of Emissions

From a human health perspective, the Facility emissions that have air quality standards established by Mozambique Decree No. 67/2010 and by the WHO are:

- oxides of nitrogen (NO_x), the sum of nitric oxide (NO) and nitrogen dioxide (NO_2), expressed as nitrogen dioxide;
- sulphur dioxide (SO_2);
- total suspended particles (TSP; eg dust);
- particulate matter of aerodynamic diameter ≤10µm (PM_{10});
- particulate matter of aerodynamic diameter ≤2.5µm ($PM_{2.5}$);
- carbon monoxide (CO); and
- carcinogenic pollutants (i.e. emissions from diesel consumption).

In relation to impacts on sensitive ecology, the potential impacts associated with emissions from NO_X and SO_2 will be assessed through impacts directly to air quality.

GHG emissions are considered separately in *Section 12.3*.

12.2.2 Air Quality Impact Assessment Criteria

Assessment Criteria for the Protection of Human Health

The IFC Guidelines defer to the WHO Air Quality Guidelines Global Update 2005, as set out in *Table 12.1*. Both Mozambique national air quality standards and WHO standards have been used in the assessment. However, as the Mozambique standards do not cover impacts associated with PM_{10} and $PM_{2.5}$, the WHO Guidelines are considered in this assessment.

Table 12.1 Air Quality Standards and Guidelines

Pollutant	Averaging Period	Guideline Value (µg/m³)	
		WHO	Mozambique Decree no. 67/2010
SO_2	1-year		**40**
	24-hour	125 (Interim target-1) 50 (Interim target-2) 20 (guideline)	**100**
	1-hour		**800**
	10-minute	500 (guideline)	**500**
NO_2*	1-year	**40 (guideline)**	10
	24-hour		
	1-hour	**200 (guideline)**	190
TSP	1-year		**60**
	24-hour		**150**
PM_{10}	1-year	**70 (Interim target-1)** **50 (Interim target-2)** **30 (Interim target-3)** **20 (guideline)**	
	24-hour	**150 (Interim target-1)** **100 (Interim target-2)** **75 (Interim target-3)** **50 (guideline)**	
$PM_{2.5}$	1-year	**35 (Interim target-1)** **25 (Interim target-2)** **15 (Interim target-3)** **10 (guideline)**	
	24-hour	**75 (Interim target-1)** **50 (Interim target-2)** **37.5 (Interim target-3)** **25 (guideline)**	
CO	8-hour average		**10 000**
	1-hour average		**30 000**
	15-minute		**100 000**
	30-minute		**60 000**
Ozone	8-hour daily maximum	160 (Interim target-1) 100 (guideline)	**120**
	1-hour average		**160**
	24-hour		**50**
Benzene	One-year mean		**4.4 x 10-6**

*MICOA has authorised the Project to use the WHO NO_2 standard instead of the Mozambican NO_2 standard.

The Project will comply with the limits shown in **bold**.

Assessment Criteria for the Protection of Ecological Habitats

Impacts relating directly to air quality (ie NO_x and SO_2) are not habitat or species specific. NO_x and SO_2 are especially relevant in this context as they both play a role in the acidification of water and soil, and NO_x also contributes to eutrophication. The criteria used in this assessment are provided in *Table 12.2*.

Table 12.2 Air Quality Critical Levels Used for the Assessment of Impacts on Sensitive Ecological Receptors

Pollutant	Averaging Period	Guideline Value (µg/m³)	Source
NO_x	Annual mean	30	ECAQS*
SO_2	Annual mean	20	ECAQS*

* derived from the European Commission Air Quality Standard (ECAQS).

Significance Criteria

The method used to assess significance differs from the impact assessment methodology described in *Chapter 3* of this report. It is more appropriate to assess air quality impacts and is in keeping with IFC Guidelines.

The significance of the predicted impacts was determined by comparison to the air quality standards and guidelines discussed above. The significance of impacts is primarily based upon whether or not these air quality standards are exceeded or contribute a substantial proportion of airborne pollutants in the local airshed.

IFC differentiates the significance of impacts based upon the existing baseline air quality in the vicinity of a proposed development. Essentially, air quality impacts are based upon whether there is a significant risk of the existing baseline air emissions to result in air quality guidelines being exceeded. The IFC Guidelines state:

> *'Projects with significant sources of air emissions, and potential for significant impacts to ambient air quality, should prevent or minimise impacts by ensuring that:*
> - *Emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards, or in their absence, the current WHO Air Quality Guidelines, or other internationally recognised sources.*
> - *Emissions do 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 (ie in an undegraded airshed).'*

When considering the significance of impacts to human health in the context of air quality, all receptors are considered equally sensitive. This arises from the fact that all receptors will experience similar health effects when exposed to increases in airborne pollution. Therefore, the significance of impact is dependent on the magnitude of impact, with due regard to the existing baseline (the airshed is defined as undegraded, based on initial baseline data). The significance criteria used in this study for the assessment of human health follow the IFC Guidelines, but are expanded upon to provide an indication of the importance of impacts.

When considering sensitive ecological receptors, generally all receptors are considered to be equally sensitive to the main pollutants of interest (NO_x and SO_2).

Magnitude Criteria

The magnitude of the impact is based the Project Contribution (PC); this is the impact arising solely from Project-related emissions. The PC was calculated using predictive techniques based on dispersion modelling of the Project emissions. To determine the significance of those impacts, consideration is required of the existing baseline. The PC added to the existing baseline is described as the Predicted Environmental Concentration (PEC).

The significance of impacts is therefore defined in terms of the magnitude of impacts (ie the PC), and whether the baseline pollution concentrations are above or below the air quality standards. Using this approach, the significance criteria for air quality are defined in *Table 12.3*.

Table 12.3 Significance Criteria for Assessment of Airborne Pollutants [(1)]

Significance of Impact	Magnitude of Impact
NEGLIGIBLE	***Negligible***: PC <25% of AQS
MINOR	***Small***: PC between 25% and 50% of AQS and PEC <100% of AQS
MODERATE	***Medium***: PC between 50% and 75% of AQS, and PEC <100% AQS; or ***Medium***: PC between 25% and 50% of AQS, and PEC >100% of AQS
MAJOR	***Large***: PC between 75% and 100% of AQS, and PEC <100% AQS; or ***Large***: PC between 50% and 75% of AQS, and PEC >100% of AQS
CRITICAL	***Very Large***: PC>100% of AQS; or ***Very Large***: PC between 75% and 100% of AQS and PEC >100% of AQS

Key:
PC: Project Contribution.
PEC: Predicted Environmental Concentration.
AQS: Air Quality Standard.

(1) The significance for humans and ecology are treated as the same in light of no alternative information.

12.2.3 Air Dispersion Model

Dispersion modelling is used to predict concentrations of pollutants at ground-level locations outside the Project boundary. The following text provides an overview of the scenarios assessed in the air dispersion model.

Operating Scenarios

The air quality assessment has evaluated the potential impacts from the following four operating scenarios:

Scenario 1:
- Trains 1 and 2 operating normally; and
- no flaring.

Scenario 2 (short-term assessment with maximum flaring event):
- Trains 1 and 2 operating normally; and
- 60 minutes emergency flaring event on one flare.

Scenario 3:
- Trains 1 to 6 operating normally; and
- no flaring.

Scenario 4 (short-term assessment with maximum flaring event):
- Trains 1 to 6 operating normally; and
- 60 minutes emergency flaring event on three flares.

Model inputs for the LNG Trains and flares and other details for the model parameters are include in *Annex C*.

12.2.4 Air Dispersion Model Results

Human Receptors

The significance of the predicted impacts is assessed using the criteria set out in *Section 12.2.2*. The PCs are based upon the maximum predicted impact for any of the five years of meteorological data. The results of the air dispersion modelling assessment for human receptors indicate a NEGLIGIBLE impact significance rating for most scenarios; the exceptions to this are discussed below by the potential pollutant of interest.

NO_2

The results of the dispersion modelling show that NO_2 concentrations will be highest within the Afungi Project Site. NO_2 concentrations would be greatest during an unlikely scenario involving emergency flaring on all three flares with six LNG Trains in operation. However, even in this scenario, the WHO and Mozambican Guideline Values would not be exceeded.

Air quality within the confines of the Afungi Project Site presents a potential occupational health and safety concern for the Project, but does not present a potential impact to community health. However, in this six Train/three flare scenario, modelling identified this event could result in a NO_2 emission concentration of 64.5µg/m³ outside the Afungi Project Site. This concentration is between 25 and 50 percent of AQS and PEC <100% of AQS (as discussed in *Table 12.3*). Therefore, the impact significance has been assessed as MINOR for this scenario. *Figure 12.1* shows the maximum one-hour dispersion of NO_2 emissions from the LNG Facility associated with the six Train/three flare modelled scenario.

SO_2

Similar to NO_2, the results of the dispersion model demonstrate that SO_2 concentrations will be highest within the Afungi Project Site, but below WHO and Mozambican Guideline Values. The impact to community health is expected to be of NEGLIGIBLE impact significance in the majority of circumstances; the exceptions are related to the 24-hour maximum concentration in the following scenarios:

- two Trains (no flaring): 7.54µg/m³ (MINOR impact significance); and
- six Trains (no flaring): 11.7µg/m³ (MODERATE impact significance).

Contour plots (*Figure 12.2* and *Figure 12.3*) have been generated to show the dispersion of SO_2 emissions from the LNG Facility in these scenarios.

Other Pollutants (TSP, PM_{10} and $PM_{2.5}$)

The results of the dispersion modelling demonstrate that impacts for TSP, PM_{10} and $PM_{2.5}$ will be of NEGLIGIBLE significance.

Sensitive Ecological Receptors

The significance of the predicted impacts is assessed using the criteria set out in *Section 12.2.2*. The PCs are based upon the maximum predicted impact for any of the five years of meteorological data. The results of the air dispersion modelling assessment for sensitive ecological receptors indicate the Project emissions will be of NEGLIGIBLE impact significance for all scenarios modelled. *Figure 12.1* to *Figure 12.3* show the extent and concentration of NO_2 and SO_2 in the modelled scenarios.

40°30'0"E
40°35'0"E
10°45'0"S
10°50'0"S

Palma Bay
Palma
Barabarane
Ntaunadje
Quitupo
Nambuimbui
Nacabande
Quidjeri
Namacande
Quitunda
Senga
Patacua
Maganja
Afungi Peninsula

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

- Villages / Settlements
- Local Roads
- Regional Roads
- Afungi Project Site
- Flare Sources
- Point Sources
- Buildings

Short term (1hr max) NO2

(µg/m³)	% WHO	% MOZ
200	100%	105%
100	50%	53%
50	25%	26%
20	10%	11%
10	5.0%	5.3%
5	2.5%	2.6%
4	2.0%	2.1%
3	1.5%	1.6%
2	1.0%	1.1%
1	0.5%	0.5%

MAIN MAP SCALE:
0 1 2 3
Kilometers
N

TITLE:
Figure 12.1:
Short term (1hr max) NO2 Impact during Emergency Flaring (Scenario 4; 6 Trains Operational)

CLIENT:
Anadarko Moçambique Área 1, Lda
eni

DATE: Oct 2013	CHECKED: YV	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 60 000

DRAWING: Short term (1hr max) NO2 Impact during Emergency Flaring.mxd
REV: A

ERM
Great Westerford Building
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Impacto Projectos e Estudos Ambientais
ERM

Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation. ERM, 2012. Inset Map: Esri Data & Maps

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40°30'0"E

40°35'0"E

10°45'0"S

10°50'0"S

Palma Bay

Palma

Barabarane

Ntaunadje

Quitupo

Nambuimbui

Nacabande

Quidjeri

Namacande

Quitunda

Senga

Patacua

Maganja

Afungi Peninsula

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

- Villages / Settlements
- Local Roads
- Regional Roads
- Afungi Project Site
- Flare Sources
- Point Sources
- Buildings

Short term (24hr max) SO2

(µg/m³)	% WHO	% MOZ
20	100%	20%
10	50%	10%
5	25%	5%
2	10%	2%
1	5.0%	1.0%
0.5	2.5%	0.5%
0.4	2.0%	0.4%
0.3	1.5%	0.3%
0.2	1.0%	0.2%
0.1	0.5%	0.1%

MAIN MAP SCALE:

0 1 2 3

Kilometers

N

TITLE:

Figure 12.2:
Short term (24hr max) SO2 Impact during Normal Operation (Scenario 1; Train 1 and 2 Operational)

CLIENT:

Anadarko
Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: YV	PROJECT: 0133576
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DRAWING:
Short term (24hr max) SO2 Impact during Normal Operation.mxd

REV: A

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Rondebosch, 7725
Cape Town, SOUTH AFRICA
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Impacto
Projectos e Estudos Ambientais

ERM

Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
ERM, 2012. Inset Map: Esri Data & Maps

SIZE: A3

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40°30'0"E

40°35'0"E

10°45'0"S

10°50'0"S

Palma Bay

Palma

Barabarane

Ntaunadje

Quitupo

Nambuimbui

Nacabande

Quidjeri

Namacande

Maganja

Afungi Peninsula

Quitunda

Senga

Patacua

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Legend

- Villages / Settlements
- Local Roads
- Regional Roads
- Afungi Project Site
- Flare Sources
- Point Sources
- Buildings

Short term (24hr max) SO2

(µg/m³)	% WHO	% MOZ
20	100%	20%
10	50%	10%
5	25%	5%
2	10%	2%
1	5.0%	1.0%
0.5	2.5%	0.5%
0.4	2.0%	0.4%
0.3	1.5%	0.3%
0.2	1.0%	0.2%
0.1	0.5%	0.1%

MAIN MAP SCALE:

0 1 2 3

Kilometers

N

TITLE:

Figure 12.3: Short term (24hr max) SO2 Impact during Normal Operation (Scenario 3; 6 Trains Operational)

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: YV	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 60 000

DRAWING: Short term (24hr max) SO2 Impact during Normal Operation (Scenario 3; 6 Trains Operational).mxd

REV: A

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Great Westerford Building
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Impacto Projectos e Estudos Ambientais

ERM

Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation. ERM, 2012. Inset Map: Esri Data & Maps

SIZE: A3

T:\GIS Projects\0133576_Anadarko_Moz_LNG\Mapping\MXD\ES\A\Chapter12\Short term (24hr max) SO2 Impact during Normal Operation (Scenario 3; 6 Trains Operational).mxd

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Mitigation Measures

Air dispersion modelling indicates that the two Train operating scenarios will likely present minimal impact to air quality outside the Afungi Project Site. However, when expanding to six Trains, a potential impact on air quality was identified through modelling. The current modelling results indicate that further consideration of the design of the LNG Facility may be necessary to avoid the potential of exceeding air quality standards during operation.

To mitigate potential impacts to air quality, it is recommended that during FEED further iterations of the air dispersion modelling are conducted to inform final design to minimise SO_2 emissions.

Residual Impact

Potential impacts on air quality can be identified through future iterations of air dispersion modelling during FEED. Air dispersion modelling can identify what design alternatives are best suited to reduce potential air quality impacts for the Project. At this stage, the use of appropriate technology or design revisions can be implemented to minimise potential impacts to air quality. Future iterations of air dispersion modelling are expected to inform the design of the Project, and will likely reduce all air quality impacts to NEGLIGIBLE. With the implementation of the above control and mitigation measures, impact intensity and magnitude are reduced to Low, and thereby impact significance is likely to be reduced to MINOR.

Table 12.4 Operational Phase Air Quality Impacts to Human Receptors

Pollutant	Without Mitigation	Residual Impact (with Mitigation)
Scenario 1: Two Trains/No Flaring		
NO_2	**NEGLIGIBLE**	**NEGLIGIBLE**
SO_2	**MINOR** (maximum 24-hr PC)	**NEGLIGIBLE**
TSP, PM_{10} and $PM_{2.5}$	**NEGLIGIBLE**	**NEGLIGIBLE**
Scenario 2: Two Trains/ 60-min Flaring (One Flare)		
NO_2	**NEGLIGIBLE**	**NEGLIGIBLE**
SO_2	**NEGLIGIBLE**	**NEGLIGIBLE**
TSP, PM_{10} and $PM_{2.5}$	**NEGLIGIBLE**	**NEGLIGIBLE**
Scenario 3: Six Trains/No Flaring		
NO_2	**NEGLIGIBLE**	**NEGLIGIBLE**
SO_2	**MODERATE** (maximum 24-hr PC)	**NEGLIGIBLE**
TSP, PM_{10} and $PM_{2.5}$	**NEGLIGIBLE**	**NEGLIGIBLE**
Scenario 4: Six Trains/ 60-min Flaring (Three Flares)		
NO_2	**MINOR** (maximum one hr PC)	**NEGLIGIBLE**
SO_2	**NEGLIGIBLE**	**NEGLIGIBLE**
TSP, PM_{10} and $PM_{2.5}$	**NEGLIGIBLE**	**NEGLIGIBLE**

Table 12.5 Operational Phase Air Quality Impacts to Ecological Receptors

Pollutant	Without Mitigation	Residual Impact (with Mitigation)
	All Scenarios	
NO_2	**NEGLIGIBLE**	**NEGLIGIBLE**
SO_2	**NEGLIGIBLE**	**NEGLIGIBLE**
TSP, PM_{10} and $PM_{2.5}$	**NEGLIGIBLE**	**NEGLIGIBLE**

12.3 GREENHOUSE GAS EMISSIONS/CLIMATE CHANGE

12.3.1 Overview

This section provides an assessment of the potential impacts of the Project's contribution to climate change through GHG emissions. The carbon footprint of both the construction and operational phases of the LNG Facility have been estimated. However, there is significant uncertainty in these estimates given the early stage of Project design. It should be noted that the ongoing design of the Project through FEED will seek to optimise efficiency. Therefore, the GHG emission sources and estimated volumes assessed herein are considered to reflect a worst-case scenario.

The only publicly available detailed inventory of Mozambique's national GHG emissions is for the years 1990 and 1994. This inventory was published in 2003 by the Ministry for Co-ordination of Environmental Affairs as part of Mozambique's First National Communication to the UN Framework Convention on Climate Change (UNFCCC). The accuracy of the GHG emissions estimate in the National Communication cannot be verified; however, it is the best available data upon which to base this assessment.

Mozambique's national GHG emissions are estimated to be 15.9 $MtCO_2e$ in 1994, as detailed in *Table 12.6*. The vast majority of GHG emissions arose from land use, land use change and forestry (LULUCF) (48.7 percent) and agriculture (29.6 percent). The energy sector (which includes gas processing) accounted for 11.6 percent of emissions in 1994.

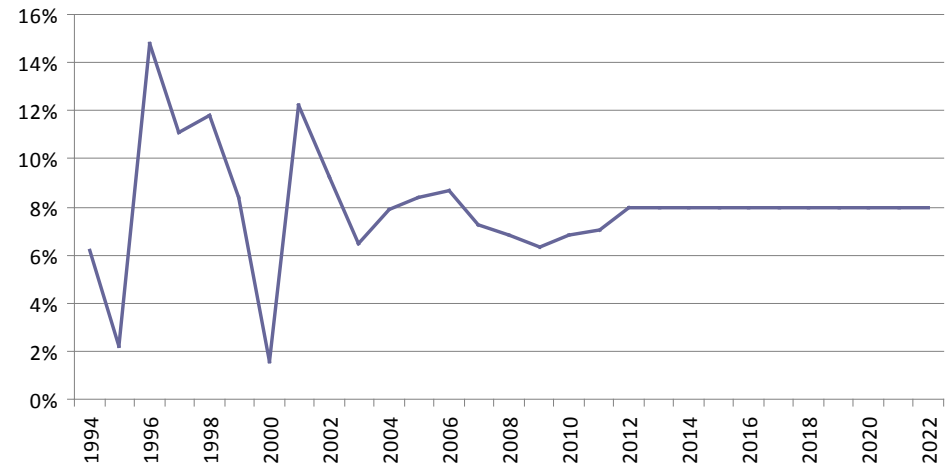
Table 12.6 Mozambique's National GHG Emissions 1990 and 1994

Emission Source	1990	1994	1990	1994
	Total $MtCO_2e$		% of Total	
Energy	2.437	1.844	27%	11%
Industrial Processes	0.04	0.051	0%	0%
Agriculture	3.897	4.715	43%	29%
Land Use Change and Forestry	2.163	7.743	24%	48%
Waste	0.42	1.554	4.7%	9%
Total $MtCO_2e$	**8.957**	**15.907**		

Source: UNFCCC, 2006.

In the absence of actual GHG emissions data, GDP growth has been used as a proxy for emissions growth from 1994 to the present. *Figure 12.4* illustrates the variation in Mozambique's GDP growth rate from 1994 to 2011. According to the World Bank, following the end of the civil war in the early 1990s growth was turbulent but has settled over the past decade. The historic average growth of 8 percent per annum has been used to project GHG emissions from 2012 to 2028. The extent of the increase in national GHG emissions is somewhat dependent on policy, legislative framework, the type of development (eg manufacturing, mining, oil and gas) and GDP growth in Mozambique, and the timing thereof. It is, however, the best estimate of potential future emissions in the country.

Figure 12.4 Mozambique GDP Growth Rates 1994–2022

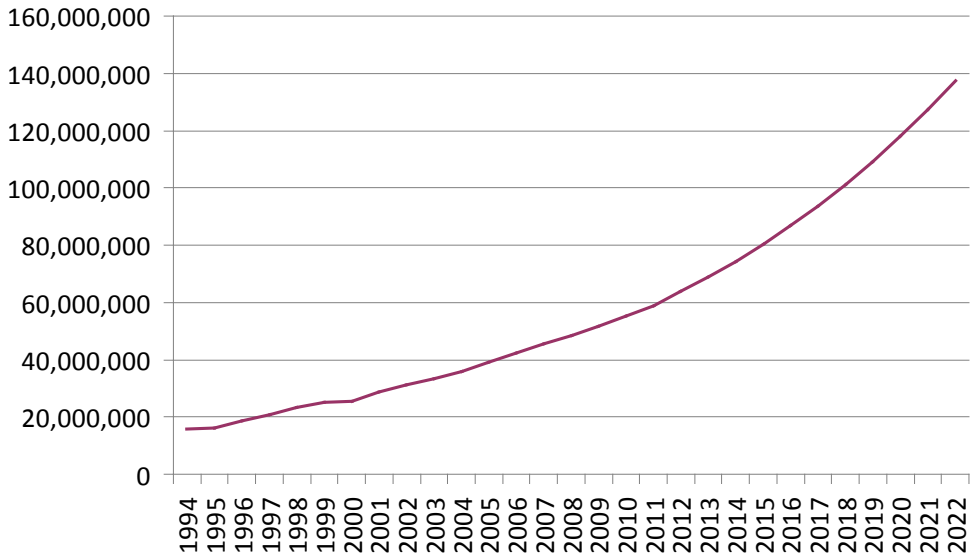


Source: World Bank Data.

Figure 12.5 illustrates Mozambique's estimated historic and projected national GHG emissions, based on GDP growth from a 1994 baseline.

In summary, Mozambique's GHG emissions were low in 1994 but, based on GDP growth rate, they are projected to grow significantly in the coming decades.

Figure 12.5 ***Mozambique's National GHG Emissions (tCO_2e) Projects Based on GDP Growth***



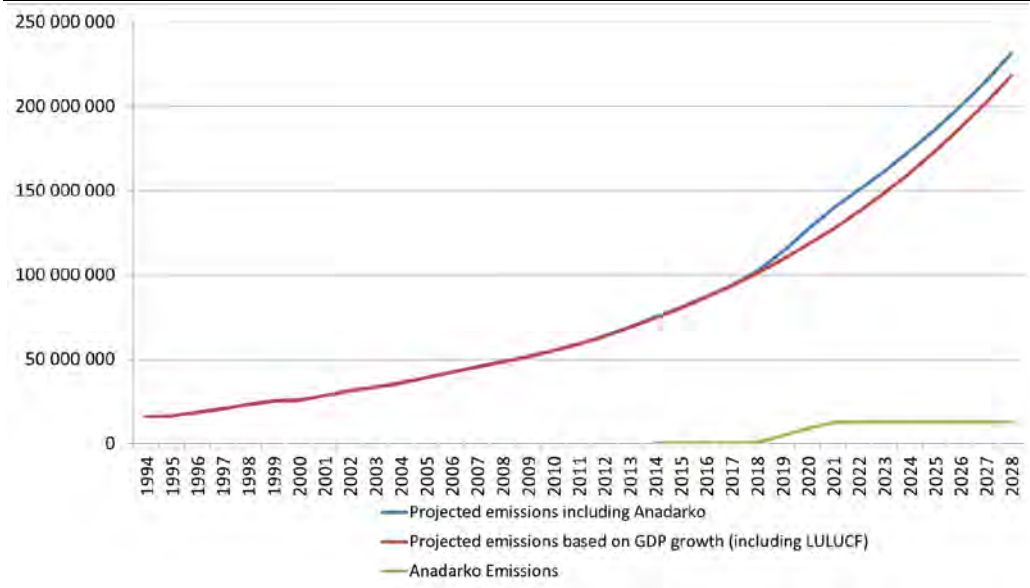
Source: ERM, 2012.

12.3.2 *Impact of Project GHG Emissions on Mozambique's National Emissions*

Impact Assessment

The impact of the estimated operational GHG emissions from the Project against Mozambique's national GHG inventory has been assessed by comparison with an emissions trajectory from 1994 to 2028. This has been determined based on historic and projected economic growth and development pathways, as illustrated in *Figure 12.6*.

Figure 12.6 ***Comparison of Mozambique and Project GHG Emissions***



The blue line shows the increase in national GHG emissions once the Project is fully operational (based on six LNG Trains). The green line shows the level of direct GHG emissions from the Project. It is evident that by 2022, the first year of full operations of the LNG Facility, GHG emissions from the Project could account for nearly 10 percent of Mozambique's national GHG emissions. For details and assumptions on how the emissions from the Project were calculated, see *Annex C.*

Given growth in national emissions over time, by 2028 the Project could account for around 6 percent of national GHG emissions. The divergence between the maroon and blue lines in the figure above illustrates the proportion of national emissions accounted for by the Project. *Table 12.7* shows the percentage increase in national GHG emissions of the Project from 2012 to 2028.

Table 12.7 Comparison of Project GHG Emissions with Projected National Emissions (tCO_2e)

Year	Mozambique National Emissions*	LNG Estimated Emissions	Percentage Increase in National Emissions
2014	74,300,843	545,967	0.74
2015	80,244,910	362,855	0.45
2016	86,664,503	362,855	0.42
2017	93,597,663	362,855	0.39
2018	101,085,477	895,827	0.89
2019	109,172,315	4,745,980	4.21
2020	117,906,100	8,886,428	7.54
2021	127,338,588	12,432,605	9.77
2022**	137,525,675	12,934,474	9.41
2023	148,527,729	12,934,474	8.71
2024	160,409,947	12,934,474	8.06
2025	173,242,743	12,934,474	7.47
2026	187,102,162	12,934,474	6.91
2027	202,070,335	12,934,474	6.40
2028	218,235,962	12,934,474	5.93

Key:
* Mozambique National Emissions projected from 1994 baseline using actual and projected 8% GDP growth.
** 2022 is the first year of full operation.

The Project is estimated to emit approximately 13 million tonnes of CO_2 per year during full operation of six LNG Trains. The Project GHG emissions will increase the level of Mozambique's GHG emissions by 9.4 percent when six LNG Trains are projected to be operational in 2022. To determine whether this is significant or not, the increase in GHG emissions is discussed against the following aspects:

- annual GHG emissions increase;
- future GHG regulation; and

- benchmarking against other LNG facilities worldwide.

These are discussed in turn below.

Annual GHG Emissions Increase

The GHG emission projection based on GDP growth assumes an 8 percent increase in GHG emissions annually, as discussed in *Section 12.3.1* above. This annual increase rate could represent an over- or underestimation of future GHG emissions, but there are no recorded data available to calibrate it against. Assuming that GHG emissions increase as forecasted (8 percent per year), the addition of the Project will increase Mozambique's GHG emissions by an equivalent amount during the first few years of operation. As national GHG emissions rise (as set out in *Table 12.7*), the proportion that the Project contributes to Mozambique's national GHG emissions decreases due to the increase of other GHG emission sources.

Future Greenhouse Gas Regulation

Mozambique, as a Least Developed Country (1), does not currently have an obligation to reduce GHG emissions, and it unlikely to take on either voluntary or mandatory targets in the future. The country's main focus in relation to climate change is to ensure the safety of vulnerable communities, environments and infrastructure in the face of changing disease distribution, crop productivity and extreme weather events such as droughts, floods and cyclones.

However, the government acknowledges the need for Mozambique to play its part in the international response to climate change, but needs finance, technology and capacity building to do so. Whilst there is unlikely to be legislation on GHG emissions in the short term, the international community may look to Mozambique to develop a green, low-GHG emissions economy given the high GHG emissions associated with its operations. As a result, the Project and other LNG processing companies in the country may face pressure to reduce GHG emissions voluntarily.

Benchmark against International LNG Facilities

Benchmarking the GHG emissions intensity of the Project against other LNG projects provides a measure of its performance against the industry average. A comparative analysis has been undertaken to compare the Project's GHG emissions against a number of other LNG facilities. The confidence in this comparison is low, as the assumptions on which emissions were calculated for the other LNG projects are not known and may differ from the assumptions made for this Project. The GHG emissions intensity of LNG facilities is

(1) For the comprehensive United Nations list of Least Developed Countries, see www.un.org.

influenced by a range of internal (technology) and external (environmental/geographic) factors, as indicated in *Table 12.8*.

Table 12.8 Factors Influencing Greenhouse Gas Emissions Intensity

Technology and Process	External
Choice of liquefaction technology Assumptions regarding the amount of flaring that may be required Power generation – choice of energy source, technology and configuration Waste heat recovery	The CO_2 content of the gas entering the LNG Facility The ambient temperature at the LNG Facility (combustion efficiency improves with cooler temperatures)

Source: ERM, 2012.

The production capacity of the Project is 30 million tonnes of LNG per year when all six Trains are in full operation. With an estimated annual carbon footprint of 12.15 $MtCO_2e$ for the LNG processing activities (1), this is equivalent to 0.405tCO_2e/tonne LNG. Without mitigation, the proposed Project may increase GHG emissions in Mozambique by approximately 6 to 10 percent.

The extent of the impact is national, as it is Mozambique's GHG emissions that are directly increased due to the impact of the Project. Although the greenhouse effect is transboundary and global emissions are directly affected, this work assesses the impact on Mozambique's GHG emissions. The duration of the impact is regarded as permanent, as science has indicated that the persistence of carbon dioxide in the atmosphere is said to range between 100 and 500 years and therefore continues beyond the life of the project. The increase in Mozambique's national GHG emissions and the long residence time in the atmosphere indicates that the impact would have a Medium intensity during the construction phase when GHG emissions are low, and a High intensity during the operational phase, when GHG emissions are orders of magnitude higher. Given the international extent and permanent nature of the impacts as well as the high intensity of the impact on Mozambique's national GHG emissions, the magnitude of the negative impacts is considered to be Medium during the construction phase and High during the operational phase. The probability of increased levels of GHG emissions with the proposed Project is definite.

In light of the above, the significance of the impact of GHG emissions from the Project on Mozambique's national GHG emissions can be considered MAJOR.

The degree of confidence in the assessment is Medium, as detailed design has not been completed.

(1) Comparison only relates to emissions from LNG processing activities, and not emissions associated with transport and other site activities. This ensures a more representative assessment against other facilities.

Mitigation Measures

Mitigation is centred on optimising energy efficiency during design (FEED) and implementing those efficiencies during construction and operations. The Project design has an opportunity to influence the overall impact of the Project and associated activities on GHG emissions, by ensuring that the final design includes energy-efficient and low GHG emissions options where practical. These measures could include:

- Fugitive emissions: fugitive GHG emissions arise from the escape of methane from valves, flanges, seals and connectors associated with LNG processing, as well as the combined vapours from LNG storage tanks and ship loading systems. In the interests of reducing GHG emissions as well as safety, during FEED the facility should be designed to minimise fugitive emissions. The Project will implement leak detection and repair programme for potential fugitive emissions from valves, flanges, seals and connectors associated with LNG processing and storage.

  The vapour recovery compression facilities, which have been included as part of the Project, will recover vapours generated from the LNG tanks and LNG export vessels during LNG loading. Recovered vapours will be returned to the methane refrigerant loop for cooling and subsequent reliquefaction. The recovery and reprocessing of vapours during the ship loading process reduces GHG emissions associated with venting and flaring. The contractor will survey facilities for fugitive emissions prior to turnover to the operator.

- Transportation: optimisation of transport logistics (eg equipment, products and people) and the use of energy-efficient vehicles and machinery and maintain them in good working condition to reduce fuel consumption.

  Green buildings: the majority of GHG emissions linked to offices and accommodation are associated with heating/cooling. By building well-insulated buildings that use renewable energy and efficient cooling systems, the carbon footprint associated with these activities will be reduced, as will the cost of fuel and energy. A number of initiatives can be implemented when constructing the camps and offices that will help reduce electricity generation and GHG emissions. Whilst the majority of these initiatives may not significantly reduce the overall carbon footprint, they would improve the efficiency of the buildings. The Project will reduce electricity consumption and GHG emissions at camps and other buildings using Good International Industry Practice as far as practical. Initiatives should include:

  - solar power: reductions in electricity use from buildings can be expected if all hot water is provided from water heaters and photovoltaic panels that can reduce fossil fuel-generated electricity;

- insulation: well-insulated walls and ceilings will reduce temperature extremes within the buildings, leading to more comfortable living/working conditions and reduced air conditioning requirements;

- lighting: use of natural light where possible, and compact fluorescent or LED lighting throughout the site will reduce the need for electricity generation;

- cooling: use of energy-efficient air conditioners that use refrigerant gases with a low global warming potential (such as R134); and

- buildings (particularly offices): will be fitted with sensors, timers and control systems that allow lights and equipment to switch off or go onto standby when not in use (eg overnight).

The contractor will select and use best available technology to the extent practical to contribute towards electricity savings and thereby reduce the overall operational carbon footprint of the Project.

Residual Impacts

The scale and nature of the Project means that while good practice can be employed to reduce GHG emissions, the overall magnitude and likelihood of the impact is not expected to change. Thus, a residual impact of MAJOR significance is expected.

Table 12.9 Impact of Project GHG Emissions on Mozambique's National Emissions

	Without Mitigation	**Residual Impact (with Mitigation)**
Construction Phase		
Duration	Permanent	Permanent
Extent	International	International
Intensity	Medium	Medium
Magnitude	**Medium**	**Medium**
Likelihood	**Definite**	**Definite**
Significance	**MAJOR**	**MAJOR**
Operational Phase		
Duration	Permanent	Permanent
Extent	International	International
Intensity	High	High
Magnitude	**High**	**High**
Likelihood	**Definite**	**Definite**
Significance	**MAJOR**	**MAJOR**

Monitoring Measures

In order to comply with IFC requirements for the annual reporting of GHG emissions, it is important for an effective and efficient data management system to be implemented from the start. The system can be used to monitor a range of sustainability indicators in addition to energy use and emissions

such as water, biodiversity, health and safety, etc. The Project will develop a GHG monitoring and reporting plan that is consistent with Mozambique and IFC requirements. Requirements of this will include:

- providing direction and commitments to sustainable development and carbon reporting;
- outlining reporting procedures in light of this policy;
- assigning roles and responsibilities to effect implementation of both internal and external carbon and sustainability reporting requirements;
- defining timing for data reporting – annual reporting of data will enable the Project to monitor progress against targets, facilitate effective progress on annual sustainability reporting and carbon management and integrate sustainability into the business;
- developing a robust monitoring and reporting methodology detailing calculations and measurements, estimations, assumptions, definitions, conversion factors, etc. In the case of measurements, this will include the type and frequency of sampling, checks on the reliability of tests, corrective measures, instructions regarding missing data, etc. The Project should integrate the monitoring and reporting of environmental data into the Project Environmental Management Systems (EMS) in terms of formalised procedures and controls. Existing management systems can be used as a vehicle for providing the framework of procedures (controls) and audit trails (documented evidence) required for reporting and auditing purposes;
- compiling a Carbon Reporting Operating Manual to provide guidance on data requirements, achieve consistency in definition interpretation and establish the foundation for an audit trail for future data verification; and
- reporting on GHG emissions and sustainability performance annually to investors, shareholders and the public.

12.4 NOISE

12.4.1 Overview

There are many sources of noise during construction and operations that have the potential to result in impacts on noise sensitive receptors (NSRs). In assessing potential impacts, communities living within the Afungi Project Site will be relocated and hence do not constitute NSRs. *Figure 12.7* maps the identified NSRs that form the basis for the noise impact assessment.

12.4.2 *Impact of Noise from LNG Processing and Shipping on Off-site Noise Sensitive Receptors*

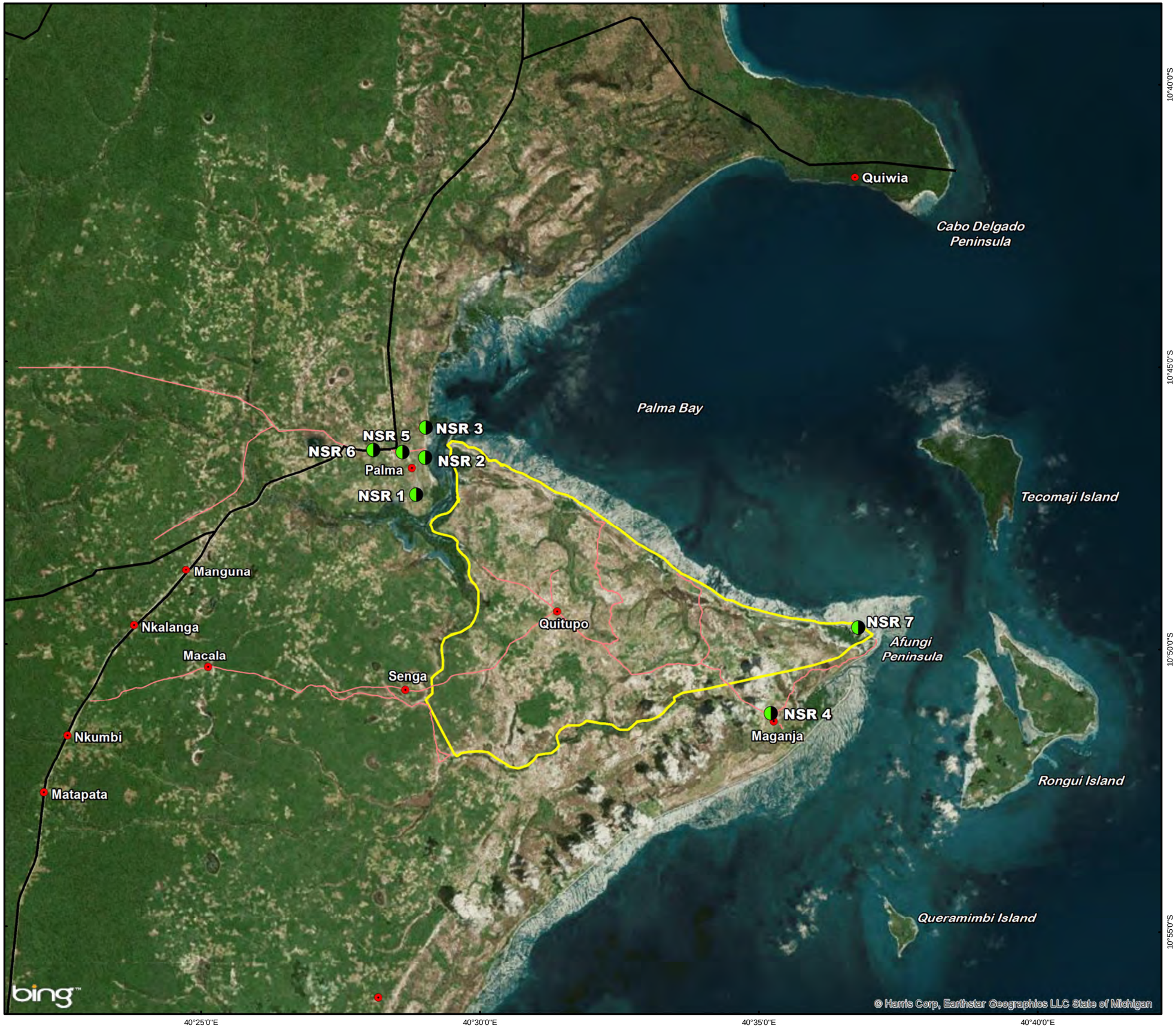
Impact Assessment

Maximum noise levels at receptors have been predicted for the construction phase. The noise values reported refer to the maximum noise level predicted at each receptor, where the construction equipment is located at the nearest point of the Project to that receptor location. This assumption represents a worst-case scenario, considering the worst combination in terms of source level and distance. *Table 12.10* to *Table 12.12* show calculated noise levels at selected NSRs during site preparation, civil works and construction of the LNG Facility. The tables also provide the noise limits as proposed by the IFC. These limits generally apply to fixed, steady noise sources (eg a power plant, refinery, LNG facility, etc).

Table 12.10 Predicted Construction Phase Noise Levels – Site Preparation

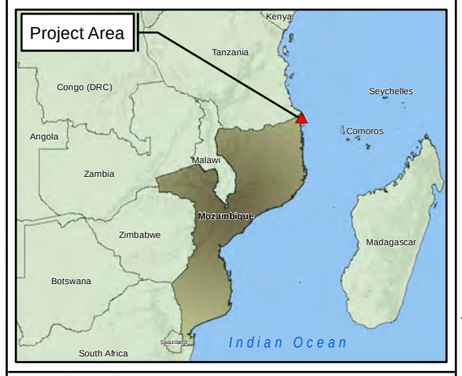
Receptor	Predicted Noise Levels, from Construction Area (dBA)						Noise Limit (dBA)	
	Process and Utility	Support Facility Area	Laydown Staging Area	Ops. Support Area	Ops. Housing Area	Air Strip	Day	Nig-ht
NSR 1	36	24	28	18	28	22		
NSR 2	37	23	27	19	29	20		
NSR 3	35	31	27	26	29	19		
NSR 4	23	23	28	29	35	18	55	45
NSR 5	34	31	26	26	28	19		
NSR 6	24	20	16	16	18	18		
NSR 7	32	24	24	30	37	26		

Source: ERM, 2012.



Legend

- Noise Sensitive Receptors
- Villages / Settlements
- Local Roads
- Regional Roads
- Afungi Project Site



MAIN MAP SCALE:

0 2 4 6

Kilometers

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Figure 12.7:
Noise Sensitive Receptors

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: RL	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 120 000

DRAWING: Noise Sensitive Receptors.mxd

REV: A

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Table 12.11 Predicted Construction Phase Noise Levels – Civil Works

Receptor	Predicted Noise Levels, from Construction Area (dBA)		Noise Limit (dBA)	
	Process and Utility Area	Operation Housing Area	Day	Night
NSR 1	39	17		
NSR 2	39	17		
NSR 3	38	17		
NSR 4	20	37	55	45
NSR 5	37	16		
NSR 6	26	15		
NSR 7	30	39		

Source: ERM, 2012.

Table 12.12 Predicted Construction Phase Noise Levels – Plant Utilities Construction

Receptor	Predicted Noise Levels, from Construction Area (dBA)		Noise Limit (dBA)	
	Process and Utility Area	Operation Housing Area	Day	Night
NSR 1	33	28	55	
NSR 2	32	28		
NSR 3	31	28		
NSR 4	17	34		45
NSR 5	31	27		
NSR 6	19	19		
NSR 7	27	40		

Source: ERM, 2012.

The predicted construction phase noise levels at all NSRs will comply with the Project's construction phase noise criteria (1) during both the daytime and night-time periods.

Maximum operational phase noise levels at receptors have also been modelled for four operational phase scenarios. The scenarios considered were:

- LNG processing;
- emergency flaring;
- shipping; and

(1)IFC and WHO threshold levels of 55 dBA for the daytime and 45 dBA for the night-time are used.

- LNG process, shipping and flaring (worst-case scenario).

Table 12.13 provides the predicted noise levels at the identified NSRs for all four scenarios.

Table 12.13 Predicted Operational Phase Noise Levels

Receptor	Predicted Noise Levels, for Operational Phase (dBA)				Noise Limit (dBA)	
	LNG Processing	Flare	Shipping	worst-case	Day	Night
NSR 1	33	23	1	34	55	45
NSR 2	33	23	-	33		
NSR 3	32	22	4	32		
NSR 4	24	7	2	25		
NSR 5	32	21	2	32		
NSR 6	21	13	1	22		
NSR 7	30	15	-	30		

Source: ERM, 2012.

The predicted operational phase noise levels comply with the project noise criteria during both the daytime and night-time periods for all scenarios. Evaluation of the "worst case" noise level (noise from the LNG process, shipping and flaring all occurring at the same time) compliance with the noise limits will still be achieved.

The noise levels at receptors are influenced predominantly by LNG processing and, in particular, by the noise contribution of the LNG Trains and the generators. Shipping noise contribution can be considered negligible. In fact, even if tugs and tankers occasionally traverse closer to sensitive receptors than modelled, they are unlikely to produce noise levels in excess of the Project noise limits.

Predicted noise contours for the four operational phase scenarios are shown in *Figure 12.8* to *Figure 12.11*

40°28'0"E 40°30'0"E 40°32'0"E 40°34'0"E 40°36'0"E

10°46'0"S 10°48'0"S 10°50'0"S 10°52'0"S

NSR 3
NSR 6
NSR 5
NSR 2
Palma
NSR 1
Palma Bay
PROCESS/ UTILITIES AREA
TRAINS 1 & 2
TRAINS 3, 4, 5, & 6
CONSTRUCTION LAYDOWN/ STAGING AREA
Quitupo
CONSTRUCTION SUPPORT FACILITY AREA
PIPELINE INLET GAS AREA
OPERATIONS HOUSING AREA
NSR 7
AIR STRIP PASSENGER TERMINAL
AIR STRIP
OPERATIONS SUPPORT AREA
Afungi Peninsula
Senga
NSR 4
Maganja
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Legend

- Villages / Settlements
- Local Roads
- Proposed Nearshore Infrastructure
- Onshore Project Footprint
- Afungi Project Site
- Noise Sensitive Receptors

LNG Processing Scenario

Noise Level dB LAeq,1h

- 30-35
- 35-40
- 40-45
- 45-50
- 50-55
- 55-60
- 60-65
- > 65

MAIN MAP SCALE:

0 1 2 3
Kilometers

N

TITLE:

Figure 12.8: Noise Contours for the LNG Processing Scenario

CLIENT:

Anadarko Moçambique Área 1, Lda
eni

DATE: Oct 2013	CHECKED: RL	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 55 000

DRAWING: Noise Contours LNG Processing Scenario.mxd

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Projection: UTM Zone 37 S, Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
ERM, 2012. Inset Map: Esri Data & Maps

SIZE: A3

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40°28'0"E 40°30'0"E 40°32'0"E 40°34'0"E 40°36'0"E

10°46'0"S 10°48'0"S 10°50'0"S 10°52'0"S

NSR 3
NSR 6
NSR 5
NSR 2
Palma
NSR 1
Palma Bay
LNG Export Jetty
PROCESS/ UTILITIES AREA
TRAINS 1 & 2
TRAINS 3, 4, 5, & 6
CONSTRUCTION LAYDOWN/ STAGING AREA
PIPELINE INLET GAS AREA
Material Offloading Facility
Pioneer Dock
OPERATIONS HOUSING AREA
NSR 7
Quitupo
CONSTRUCTION SUPPORT FACILITY AREA
AIRSTRIP PASSENGER TERMINAL
AIRSTRIP
OPERATIONS SUPPORT AREA
Afungi Peninsula
Senga
NSR 4
Maganja

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

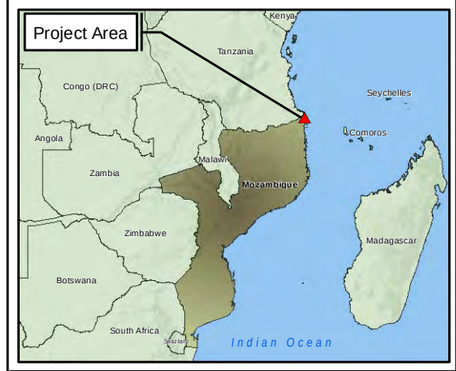
Legend

- Villages / Settlements
- Local Roads
- Onshore Project Footprint
- Afungi Project Site

Flare Scenario

Noise Level dB LAeq, 1h

- 30-35
- 35-40
- 40-45
- 45-50
- 50-55
- 55-60
- 60-65



MAIN MAP SCALE:

0 1 2 3
Kilometers

N

TITLE:

Figure 12.9: Noise Contours for the LNG Flare Scenario

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DATE: Oct 2013	CHECKED: RL	PROJECT: 0133576
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DRAWING: Noise Contours LNG Flare Scenario.mxd

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40°28'0"E 40°30'0"E 40°32'0"E 40°34'0"E 40°36'0"E

10°46'0"S 10°48'0"S 10°50'0"S 10°52'0"S

NSR 3
NSR 6
NSR 5
NSR 2
Palma
NSR 1
Palma Bay
LNG Export Jetty
Material Offloading Facility
Pioneer Dock
PROCESS/ UTILITIES AREA
TRAINS 1 & 2
TRAINS 3, 4, 5, & 6
CONSTRUCTION LAYDOWN/ STAGING AREA
PIPELINE INLET GAS AREA
OPERATIONS HOUSING AREA
NSR 7
Quitupo
CONSTRUCTION SUPPORT FACILITY AREA
AIR STRIP PASSENGER TERMINAL
AIR STRIP
OPERATIONS SUPPORT AREA
Afungi Peninsula
Senga
NSR 4
Maganja
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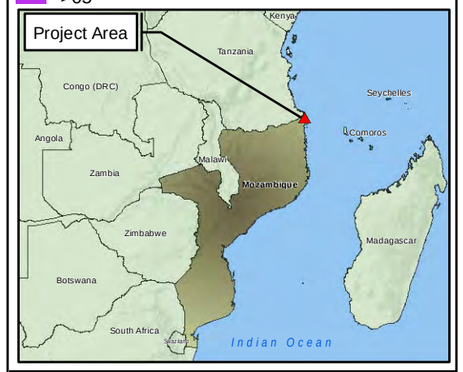
Legend

- Villages / Settlements
- Local Roads
- Proposed Nearshore Infrastructure
- Onshore Project Footprint
- Afungi Project Site
- Noise Sensitive Receptors

Shipping Scenario

Noise Level dB LAeq, 1h

- 30-35
- 35-40
- 40-45
- 45-50
- 50-55
- 55-60
- 60-65
- >65



MAIN MAP SCALE:

0 1 2
Kilometers

N

TITLE:

Figure 12.10: Noise Contours for LNG Shipping Scenario

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DRAWING: Noise Contours LNG Shipping Scenario.mxd

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10°46'0"S 10°48'0"S 10°50'0"S 10°52'0"S 10°54'0"S

NSR 3
NSR 6
NSR 5
NSR 2
Palma
NSR 1
Palma Bay
PROCESS/ UTILITIES AREA
TRAINS 1 & 2
TRAINS 3, 4, 5, & 6
CONSTRUCTION LAYDOWN/ STAGING AREA
Quitupo
CONSTRUCTION SUPPORT FACILITY AREA
PIPELINE INLET GAS AREA
OPERATIONS HOUSING AREA
NSR 7
AIR STRIP PASSENGER TERMINAL
AIR STRIP
OPERATIONS SUPPORT AREA
Afungi Peninsula
Senga
NSR 4
Maganja

bing

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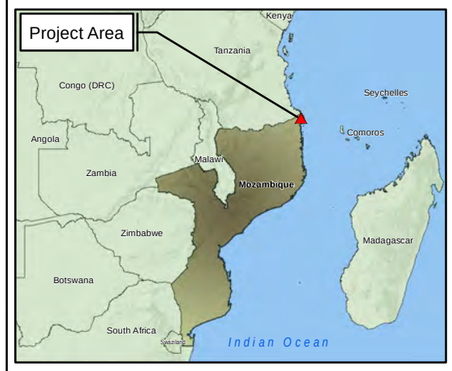
Legend

- Villages / Settlements
- Local Roads
- Proposed Nearshore Infrastructure
- Onshore Project Footprint
- Afungi Project Site
- Noise Sensitive Receptors

Processing, Flare and Shipping Scenario
Noise Level dB LAeq, 1h

- 30-35
- 35-40
- 40-45
- 45-50
- 50-55
- 55-60
- 60-65
- > 65



MAIN MAP SCALE:

0 1 2 3
Kilometers

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TITLE:

Figure 12.11: Noise Contours for the LNG Processing, Shipping and Flaring (combined) Scenario

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DRAWING: Noise Contours LNG Processing, Shipping and Flaring Scenario.mxd

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Apart from the 45dBA night-time and 55dBA daytime standard set by the IFC, the IFC Guidelines also state that '*…noise impacts should not result in a maximum increase in background levels of 3dB at the nearest receptor location off-site*'. Good International Industry Practice applies this guideline whenever ambient noise levels are already above the 45dBA/ 55dBA thresholds. The 3dB guideline was one of the criteria used to inform the rating of the noise impact. According to the modelled results (*Annex C*), the predicted increase in ambient noise does not exceed the IFC limit of 3dB at all NSRs for normal operations. While the modelled results indicate that this Guideline will not be exceeded, it should be noted that the ambient noise levels are low given the rural setting. Therefore, in the event that the 3dB guideline is exceeded on occasion, the overall noise emissions are expected to be below the 45dBa night-time and 55dBa daytime thresholds at the identified NSRs.

The noise model indicates NSRs will not experience noise impacts in excess of IFC Guidelines in either the construction or operational phases. The main reason for this is that communities living within the Afungi Project Site will be relocated. The duration of the impact is expected to be long term, with a localised extent and Negligible to Low intensity. The magnitude is expected to be Negligible to Low, and the likelihood of occurrence is Likely. Accordingly, the significance of the impact is expected to be NEGLIGIBLE to MINOR.

Mitigation Measures

The following specific measures have been identified:

- Where possible, minimise construction activities during the night time.

- Ambient noise levels at identified receptors (communities outside the Afungi Project Site) should not exceed 45dB(A) at night and 55dB(A) during the day.

- Comply with international good practice regarding the maintenance of machinery and equipment and good operational management.

Residual Impact

The residual impact significance is expected to remain as NEGLIGIBLE to MINOR during the construction and operational phases.

Table 12.14 Impact of Project Noise from LNG Processing and Shipping on Off-site Noise Receptors

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Short term	Short term
Extent	Local	Local
Intensity	Negligible to Low	Negligible to Low
Magnitude	Negligible to Low	Negligible to Low
Likelihood	**Likely**	**Likely**
Significance	**NEGLIGIBLE to MINOR**	**NEGLIGIBLE to MINOR**
Operational Phase		
Duration	Long term	Long term
Extent	Local	Local
Intensity	Negligible to Low	Negligible to Low
Magnitude	Negligible to Low	Negligible to Low
Likelihood	**Likely**	**Likely**
Significance	**NEGLIGIBLE to MINOR**	**NEGLIGIBLE to MINOR**

12.4.3 Impact of Noise from the Airstrip on Off-site Noise Sensitive Receptors

Impact Assessment

Aircraft will be landing and taking off from the airstrip several times a week. The noise model assumes an average of two arrivals and departures per day to accommodate potentially more frequent use of the airstrip during the construction phase.

L_{Amax} (peak) noise levels are sometimes used to assess sleep disturbance or to compare peak noise levels during an aircraft flyover against ambient noise levels. An aircraft noise level of L_{Amax} of 80dB (with ground effect) is commonly taken as the level above which significant community sleep disturbance can arise, assuming a degree of habituation over time. Therefore, this is the threshold above which noise impacts associated with the airstrip are considered to be significant. The following types of aircraft are expected to use the airstrip:

- Antonov 124 (this is the largest aircraft likely to be used by the Project. Using this for the noise modelling presents a conservative prediction of noise impacts);
- Cessna 208 Caravan; and
- Sikorsky S76 Sprint helicopter.

Figure 12.12 illustrates the noise contours for the Antonov 124 aircraft, which is expected to generate the highest noise levels. The L_{Amax} 80dB contour for the Antonov 124 extends approximately 10km to the north and 7km to the south of the runway (1). Two communities occur within this zone: Barabarane

(1) It has been assumed that all flights will land and take off heading to the south due to the predominance of winds from the south and south-east.

to the north, with a predicted L_{Amax} 80–90dB, and the Ngala Fishing Centre to the south, with a predicted L_{Amax} 80–85dB. The community of Barabarane will be relocated and hence is not considered to be a NSR. Ngala Fishing Centre, however, lies outside the Afungi Project Site and is considered to be a NSR. Antonov 124 aircraft would overfly this area after take-off at altitudes of approximately 1,500 to 2,000ft, depending on loading.

40°25'0"E 40°30'0"E 40°35'0"E 40°40'0"E

10°45'0"S

10°50'0"S

10°55'0"S

Cabo Delgado Peninsula

Palma Bay

Tecomaji Island

Afungi Peninsula

Rongui Island

Queramimbi Island

NSR 3

NSR 5

NSR 6

NSR 2

Palma

NSR 1

Manguna

Barabarane

Ntaunadje

Quitupo

Nambuimbui

Nacabande

NSR 7

Nkalanga

Macala

Quitunda

Quidjeri

Senga

Namacande

NSR 4

Maganja

Nkumbi

Patacua

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

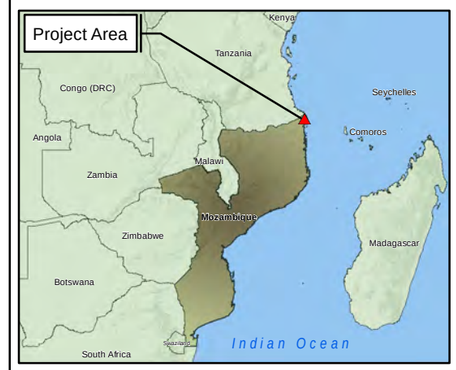
Legend

- Villages / Settlements
- Local Roads
- Regional Roads
- Afungi Project Site
- Airstrip

Airstrip Noise Contours

- LAmax 90dB
- LAmax 80dB

- Noise Sensitive Receptors



MAIN MAP SCALE:

0 2 4 6

Kilometers

N

TITLE:

Figure 12.12:
Aircraft Noise Levels - Antonov 124

CLIENT:

Anadarko Moçambique Área 1, Lda

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DATE: Oct 2013	CHECKED: RL	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 110 000

DRAWING: Aircraft Noise Levels - Antonov 124.mxd

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The L_{Amax} 80dB contour for the Cessna 208 falls within the runway area, and hence there is no significant impact from the operation of the Cessna 208.

The Sikorsky S76 is expected to fly at a cruise altitude of 1,000ft, navigating by line of sight on Visual Flight Rules. At this altitude, the aircraft is modelled as producing L_{Amax} 80dB levels within a swathe approximately 700m wide below its chosen flight path.

As one moves further from the airstrip, aircraft noise events may be comparable or below other more common peak noise levels (eg from vehicles, people, etc). Aircraft movements to and from the airstrip are likely to be more frequent during the construction phase than during the operational phase. The noise impact on Ngala would be short to Medium term in duration, and local. The intensity of the impact during the construction phase is expected to be Low to Medium, depending on the frequency of flights. The magnitude is anticipated to be Medium, with a Likely probability of occurrence. This results in an impact of MODERATE significance during construction.

During operations, flight frequency would be reduced. The expected impact would be local and long term, with a Low intensity. A Low magnitude impact is expected with a Likely probability of occurrence. Therefore, an impact of MINOR significance is expected.

Mitigation Measures

The Project will develop aviation procedures that will include the following:

- Flights at night should be avoided to the extent practicable, as there is potential to exceed the sleep disturbance impact assessment criteria at the Ngala Fishing Centre.

- The routing of helicopters should be at least 700m from identified communities.

- If practicable, departure flight routes for the Antonov 124 should be designed to make a turn to the west after a safe altitude is reached, to reduce overflying the Ngala Fishing Centre and to avoid Mbawala and Maganja on the coast.

Residual Impacts

Implementation of the mitigation methods identified above would reduce the magnitude of the construction phase impact to Low, thus reducing the construction phase residual impact to MINOR. During the operational phase, the magnitude could drop to Negligible, resulting in a NEGLIGIBLE significance impact.

Table 12.15 Impact of Noise from the Airstrip on Off-site Noise Sensitive Receptors

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Short term to medium term	Short term to medium term
Extent	Local	Local
Intensity	Low to Medium	Low
Magnitude	**Medium**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MODERATE**	**MINOR**
Operational Phase		
Duration	Long term	Long term
Extent	Local	Local
Intensity	Low	Low to Negligible
Magnitude	**Low**	**Negligible**
Likelihood	**Likely**	**Likely**
Significance	**MINOR**	**NEGLIGIBLE**

12.5 LANDSCAPE, SEASCAPE AND VISUAL

12.5.1 Overview and Approach

This section outlines the impacts on the visual landscape and seascape associated with the construction and operational phases of the Project. The landscapes and seascapes of the Study Area were defined and characterised as part of the baseline study for the purpose of this assessment (see *Chapter 6*), and are as follows:

- Wooded Inland Landscape Unit;
- Quionga to Cabo Delgado Seascape Unit;
- Palma Bay Seascape Unit; and
- Afungi Peninsula to Cabo Nondo Seascape Unit.

The impact assessment methodology used to assess visual impacts differs from the methodology presented in *Chapter 3*. Impacts are not assessed for the initial Project Footprint Area pre-mitigation, but rather for the revised layout developed based on specialist recommendations. The reason for this is that the visual assessment methodology, and photomontage exercise in particular, is preferred for the post-mitigation Project, as this provides a better understanding of what the Project might look like. Design mitigation is key to the success of minimising visual impacts. The methodology used in this section for the assessment of impacts considers several key steps, as follows:

- ZTVs (1) were defined for the main potentially visible elements of the Project, as outlined in *Chapter 4*.

(1) The ZTVs do not take account of the visual screening.

- Viewpoints across the ZTVs were selected as representative of the range of views and types of viewer likely to be affected by the Onshore Project infrastructure. The sensitivity of each viewpoint was also determined.

- Photomontage images of elements of the Onshore Project infrastructure from five viewpoint locations were developed.

- The sensitivity of each landscape, seascape and visual receptor was assessed (eg local residents, tourists, etc).

- The magnitude of change in each landscape, seascape and viewpoint was determined.

- The level of significance of impact on each landscape, seascape and viewpoint was evaluated. Significance is determined based on the sensitivity of the impact and the magnitude of change.

The detailed visual impact assessment methodology is provided in *Annex C.*

12.5.2 Context for the Visual Impact Assessment

The Offshore, Near Shore and Onshore Project components, as described in *Chapter 4,* were assessed in the development of this visual impact assessment. The Offshore Project comprises mainly the infrastructure required to develop the offshore gas fields, namely Golfinho, Prosperidade and Mamba. As this Subsea Production System will be located on the seafloor, it is not considered to present a long-term visual impact but will be of relevance in terms of short-term effects during the construction phase. The Onshore Project components will be located on the Afungi Peninsula, and long-term visual impacts will arise from the LNG Facility and associated facilities including support facilities, permanent housing, shipping, airstrip and ancillary facilities. The Near Shore Project components will be located on the coastline in Palma Bay and, as a consequence, long-term visual impacts will be associated with harbour facilities including an LNG Export Jetty, Pioneer Dock and MPD.

As mentioned in *Section 12.5.1*, impacts are not assessed in detail prior to the mitigation measures being implemented for this specialist study. The Project is likely to cause significant impacts on the immediate landscape and seascape in which it will be sited, particularly during the operational phase. Furthermore, changes to the character of the seascape and landscape of the surrounding area are likely to arise as a result of the visibility of the Project.

This section provides an overview of the landscape and seascape that will likely be impacted from the various phases of the Project:

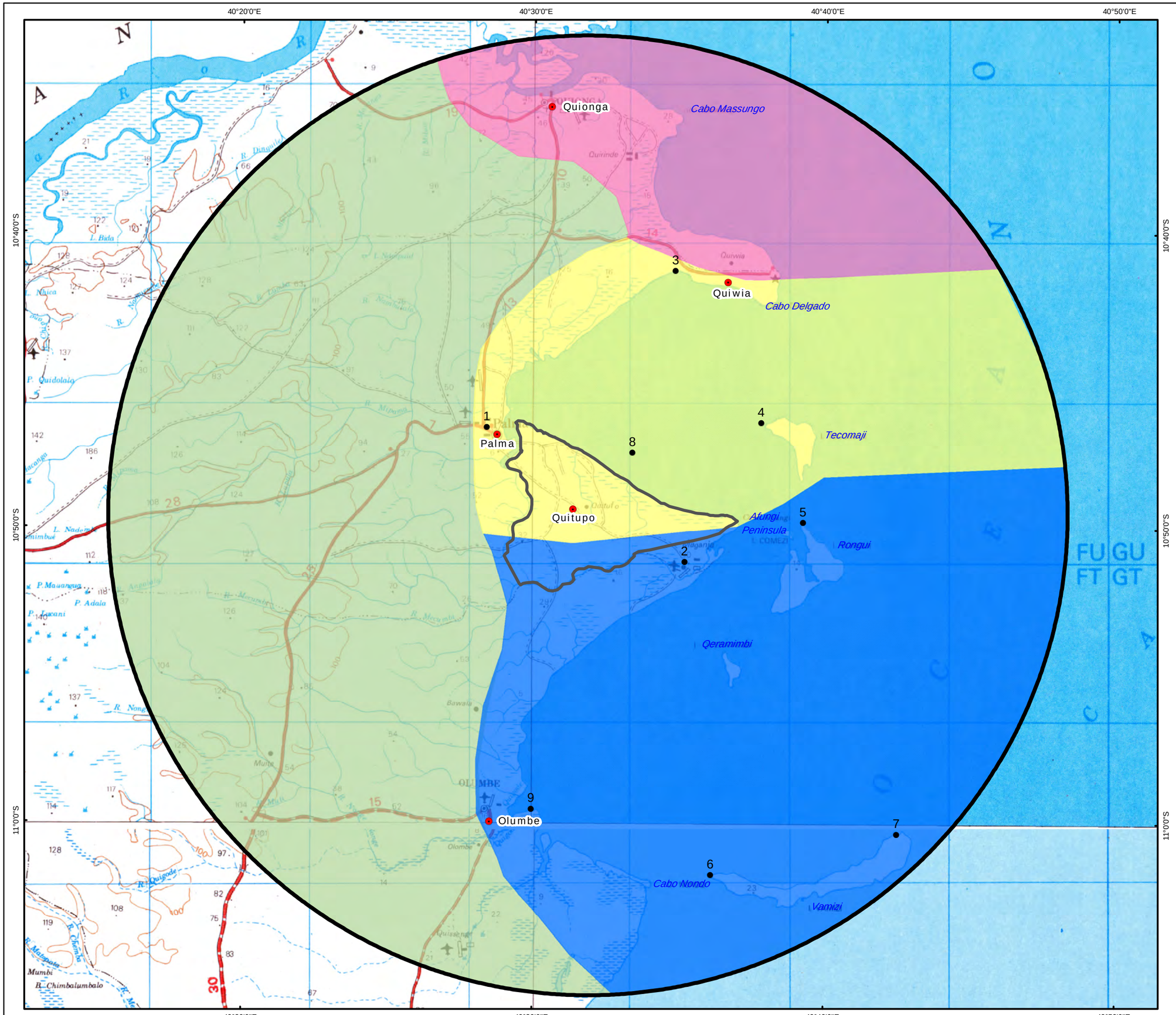
- impacts to Palma Bay Seascape Unit;
- impacts to Wooded Inland Landscape Unit;
- impacts to Quionga to Cabo Delgado Seascape Unit;

- impacts to Afungi Peninsula to Cabo Nondo Seascape Unit; and
- impacts to visual amenity from nine fixed viewpoints.

The Seascape Units, Landscape Units and viewpoints are illustrated in *Figure 12.13* and assessed in detail in *Section 12.5.4* to *12.5.8* as residual impacts.

ZTVs are presented for particular large-scale or tall elements of the Onshore Project, including the LNG tanks (45m height), flare stack (140m height), airport control tower (6m height), the Near Shore Project infrastructure (LNG Export Jetty, Future Jetty, Pioneer Dock and Multipurpose Dock or MPD). These are illustrated in *Figure 12.14* to *Figure 12.17*. These ZTVs illustrate the areas from which theoretical views of all or a part of the Project can be seen.

The ZTVs provide a worst-case scenario, as they do not take account of the visual screening provided by existing vegetation and structures. Therefore, the visibility is considered theoretical and the actual visibility of Project components is likely to be much less.



Legend

- Afungi Project Site
- 30km Buffer Study Area

Seascape Character Units

- Afungi Peninsula to Cabo Nondo Seascape Unit
- Palma Bay Seascape Unit
- Quionga to Cabo Delgado Seascape Unit

Landscape Character Areas

- Undulating wooded hinterland to Palma

Viewpoints for Visual Impact Assessment

1. Palma
2. Maganja
3. Quiwia
4. Tecomaji
5. Rongui
6. Vamisi west
7. Vamisi east
8. Location at sea within Palma Bay
9. Olumbe

SCALE: 0 5 10 Kilometers

N

TITLE:

Figure 12.13: Landscape and Seascape Character and Fixed Viewpoints

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DRAWING: Landscape and Seascape Character Viewpoints.mxd | REV: 0

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10°40'0"S

10°50'0"S

11°0'0"S

TANZANIA

Quionga

Assame

Calomba

Quiwia

Cabo Delgado Peninsula

Issa

Palma Bay

Tecomaji Island

Palma

Quitupo

Afungi Peninsula

Senga

Maganja

Rongui Island

Aienda

Queramimbi Island

Bawala

Olumbe

Vamizi Island

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Legend

- Flare Stack (140 m)
- Villages / Settlements
- Regional Roads
- Nearshore Components
- Revised Project Footprint
- Afungi Project Site
- 30km Buffer

Zone of Theoretical Visibility

- Flare Stack visible within 30km

MAIN MAP SCALE:

0 5 10

Kilometers

N

TITLE:

Figure 12.14:
Zones of Theoretical Visibility (ZTV) for Flare Stack

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10°40'0"S 10°50'0"S 11°0'0"S

TANZANIA

Quionga
Assame
Calomba
Quiwia
Cabo Delgado Peninsula
Issa
Palma Bay
Tecomaji Island
Palma
Quitupo
Afungi Peninsula
Senga
Maganja
Rongui Island
Aienda
Queramimbi Island
Bawala
Olumbe
Vamizi Island

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Legend

- Proposed LNG Tanks
- Villages / Settlements
- Regional Roads
- Nearshore Components
- Revised Project Footprint
- Afungi Project Site
- 30km Buffer

Zone of Theoretical Visibility

- LNG Tanks visible within 30km

MAIN MAP SCALE:

0 5 10
Kilometers

N

TITLE:

Figure 12.15: Zones of Theoretical Visibility (ZTV) for LNG Tanks

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10°40'0"S

10°50'0"S

11°0'0"S

TANZANIA

Quionga

Assame

Calomba

Quiwia

Cabo Delgado Peninsula

Issa

Palma Bay

Tecomaji Island

Palma

Quitupo

Afungi Peninsula

Senga

Maganja

Rongui Island

Aienda

Queramimbi Island

Bawala

Olumbe

Vamizi Island

bing™

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Legend

- Airport Control Tower (6 m)
- Villages / Settlements
- Regional Roads
- Nearshore Components
- Revised Project Footprint
- Afungi Project Site
- 30km Buffer

Zone of Theoretical Visibility

- Airport Control Tower visible within 30km

MAIN MAP SCALE:

0 5 10

Kilometers

N

TITLE:

Figure 12.16:
Zones of Theoretical Visibility (ZTV) for Airport Control Tower

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: EO'C	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 225 000

DRAWING: ZTV_Airport_ControlTower.mxd

REV: A

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Projection: UTM Zone 37 S, Datum: WGS84
Source: ERM, 2012
Inset Map: Esri Data & Maps

SIZE: A3

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40°20'0"E 40°30'0"E 40°40'0"E 40°50'0"E

10°40'0"S

10°50'0"S

11°0'0"S

TANZANIA

Quionga

Assame

Calomba

Quiwia

Cabo Delgado Peninsula

Issa

Palma Bay

Palma

Tecomaji Island

Quitupo

Afungi Peninsula

Senga

Maganja

Rongui Island

Aienda

Queramimbi Island

Bawala

Olumbe

Vamizi Island

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Legend

- Villages / Settlements
- Regional Roads
- Nearshore Project (10 m)
- Nearshore Components
- Revised Project Footprint
- Afungi Project Site
- 30km Buffer

Zone of Theoretical Visibility

- Near Shore Project visible within 30km

MAIN MAP SCALE:

0 5 10

Kilometers

N

TITLE:

Figure 12.17: Zones of Theoretical Visibility (ZTV) for Near Shore Project Components

CLIENT:

Anadarko Moçambique Área 1, Lda

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DATE: Oct 2013	CHECKED: EO'C	PROJECT: 0133576
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DRAWING: ZTV_Nearshore.mxd

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12.5.3 Mitigation Measures

The assessment assumes that the following mitigation measures will be implemented.

Design

A range of measures associated with the Project design will serve to mitigate long-term visual impacts.

- Project facilities, which require a significant footprint area, will be designed, where possible, to minimise visual impact to adjacent areas. This will be accomplished by the following measures:
    - consolidate facilities within the boundaries of the Revised Project Footprint Area (*Figure 10.3)*;
    - design fencing to follow the contour of natural and planned vegetation to maximum visual screening to the extent practicable; and
    - paint structures and buildings with colours that blend in with surrounding environment as far as practical to minimise visual impact to adjacent areas.

The Project is currently investigating the optimal solution to minimise visual impacts through design.

Construction

Construction phase mitigation measures include:

- vegetation clearance will be limited to the minimum necessary to accommodate construction within the Project Footprint Area in accordance with a Soils, Erosion Control and Reinstatement Management Plan;
- construction site lighting outside normal working hours will be restricted to the minimum required for safety and security;
- directional lighting will be used to limit light spill (ie spread of light outwards from where it is needed into adjacent areas);
- temporary use areas will be revegetated as soon as practicable after sections of work are complete in accordance with a Soils, Erosion Control and Reinstatement Management Plan; and
- dust suppression procedures will be implemented as necessary.

Operations

Much of the mitigation embedded in the Project design will serve to mitigate the long-term visual impacts of the Project. During the operational phase, site lighting will be restricted to the minimum required for safety and security and, wherever possible, directional lighting to be used to limit visual impact to adjacent areas. In addition, the Project will develop a landscaping plan that allows for visual screening by indigenous vegetation, and give consideration to the natural contours of the land.

12.5.4 Impacts of the Project on the Palma Bay Seascape Unit

Impact Assessment

The Palma Bay Seascape Unit comprises a shoreline featuring sandy beaches and estuarine salt marshes with mangrove vegetation, which are a valued landscape element and habitat asset, as described in *Chapter 6*. The entire shoreline is generally visually open with limited woody vegetation. Views are widely available from land out to sea and from sea to land, including from Tecomaji Island. The scenic quality and visual openness means that this Unit is considered to be of High sensitivity to the visual changes resulting from the development of the Project.

Construction

During construction, direct and indirect impacts will arise to the Palma Bay Seascape Unit, including:

- site clearance and topsoil stockpiling;
- construction of Onshore and Near Shore Project infrastructure;
- presence and visibility of site boundary fencing and access roads;
- presence of vessels and buoys associated with development drilling, installation of the subsea infrastructure and pipelines; and
- presence and visibility of lay barges and dredge vessels for dredging works and installation of the pipelines.

The above construction activities will result in direct visual impacts on the Palma Bay Seascape Unit.

Taking into account the temporary nature of the construction activities and associated highly visible equipment and vessels being used, these are expected to cause a visual impact of Medium magnitude. Therefore, a significance of MODERATE to MAJOR is expected.

40°20'0"E 40°30'0"E 40°40'0"E 40°50'0"E

10°40'0"S 10°50'0"S 11°0'0"S

Quionga
Cabo Massungo
Quirinde
Quiwia
Cabo Delgado
Palma
Tecomaji
Quitupo
Peninsula
Ronga
Olumbe
Cabo Vamizi

1 2 3 4 5 6 7 8 9

Legend

- Afungi Project Site
- 30km Buffer Study Area

Seascape Character Units

- Palma Bay Seascape Unit

Viewpoints for Visual Impact Assessment

1. Palma
2. Maganja
3. Quiwia
4. Tecomaji
5. Rongui
6. Vamisi west
7. Vamisi east
8. Location at sea within Palma Bay
9. Olumbe

SCALE: 0 5 10 Kilometers

N

TITLE:

Figure 12.18:
Palma Bay Seascape Unit

CLIENT: Anadarko Moçambique Área 1, Lda

DATE: Oct 2013	CHECKED: EO	PROJECT: 0133576
DRAWN: AB	APPROVED: EO	SCALE: 1 : 225 000

DRAWING: Palma Bay Seascape Unit.mxd | REV: 0

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Projection: UTM Zone 37 S, Datum: WGS84
Source: ERM, 2012
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SIZE: A3

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Operations

The introduction of the Onshore and Near Shore Project infrastructure will add large-scale man-made elements to the Palma Bay Seascape Unit, thereby establishing a new landmark feature and a point of reference in views from the wider area.

The direct effects in terms of landscape losses or changes within the Afungi Project Site are outlined below:

- permanent loss of a large area of undeveloped natural landscape comprising a mosaic of woodland, scrub and grassland; and

- alteration to the character of the coastline and beach.

Long-term visual impacts will result from the development of the LNG Facility and associated infrastructure.

Similarly, long-term visual impacts will result from the development of the Near Shore Project infrastructure, specifically the presence and visibility of the following elements:

- MOF;

- LNG Export Jetty and Future Export Jetty; and

- LNG Carriers, escort tugs and support vessels (including those for development drilling).

The Palma Bay Seascape Unit will be directly affected by the Project. The character of this seascape will also be affected by the visibility of the Project, in particular the Near Shore Project infrastructure.

The ZTVs illustrated in *Figure 12.14* to *Figure 12.17* show the extent of theoretical visibility of various Project components. In reality, the areas that will be affected by the visibility of these elements will be largely confined to the coastline, given that the inland landscape is densely wooded and will provide a measure of visual screening from many locations inland.

The Near Shore Project infrastructure will be clearly visible from Palma to the tip of Afungi Peninsula. The north shoreline of Palma Bay extending from Palma to Cabo Delgado Peninsula will also be affected by the visibility of the Near Shore Project infrastructure and taller elements of the Onshore Project, in particular the flare stack and LNG tanks. The western edge of Tecomaji Island will be visually affected. However, as the island is densely vegetated, the effects are limited to the west-facing shoreline. Occasionally areas along Tecomaji's northern coastline may be affected by the passing vessel traffic (LNG Carriers, escort tugs and support vessels, including those for development drilling). These will be identifiable as large-scale infrastructural

sea traffic, compared with the existing small-scale fishing boats and occasional vessels carrying tourists. Vessel traffic will also be seen from coastal locations on the mainland, especially upon arrival and departure from the Near Shore Project area.

The Near Shore Project infrastructure will be visible from Palma, as shown in *Figure 12.17*. The taller elements of the Onshore Project infrastructure, which will clearly visible are shown in *Figure 12.14* to *Figure 12.16*.

Passing air traffic associated with the Project will be visible overhead in the Palma Bay Seascape Unit. The presence of the Project and associated air and sea traffic will give an industrialised character to this Unit. Static elements of the Project will appear as large newly introduced elements, especially in the immediate vicinity of Afungi Peninsula.

Taking into account the extent of the coastline and seascape that will be altered as a result of the presence of Project infrastructure and sea and air traffic, a High magnitude impact is expected. Therefore, an impact of MAJOR significance is expected during the operational phase of the Project.

12.5.5 Impacts of the Project on the Wooded Inland Landscape Unit

Overview

Woodland cover is a dominant feature throughout this landscape and serves as a visual screen of the proposed development. As a result, this particular landscape is considered to be of Low sensitivity to the proposed change.

40°20'0"E 40°30'0"E 40°40'0"E 40°50'0"E

10°40'0"S 10°50'0"S 11°0'0"S

Quionga
Cabo Massungo
Quirinde
Quiwia
Cabo Delgado
Palma
Quitupo
Afungi Peninsula
I. COMEZI
I. RONGUI
Rongui
Maganja
I. QUERAMIMBI
Qeramimbi
Olumbe
C. NONDO
Cabo Nondo
I. TECOMAJI
Tecomaji
Vamizi
I. VAMIZI

1 2 3 4 5 6 7 8 9

Legend

- Afungi Project Site
- 30km Buffer Study Area

Landscape Character Areas

- Wooded Inland Landscape Unit

Viewpoints for Visual Impact Assessment

1. Palma
2. Maganja
3. Quiwia
4. Tecomaji
5. Rongui
6. Vamisi west
7. Vamisi east
8. Location at sea within Palma Bay
9. Olumbe

SCALE: 0 5 10 Kilometers

N

TITLE:

Figure 12.19:
Wooded Inland Landscape Character Area

CLIENT: Anadarko Moçambique Área 1, Lda / eni

DATE: Oct 2013	CHECKED: EO	PROJECT: 0133576
DRAWN: AB	APPROVED: EO	SCALE: 1 : 225 000

DRAWING: Wooded Inland LCA.mxd

REV: 0

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Impacto Projectos e Estudos Ambientais / ERM

Projection: UTM Zone 37 S, Datum: WGS84
Source: ERM, 2012
Inset Map: Esri Data & Maps

SIZE: A3

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Construction

During construction, there will be isolated elevated locations that will be affected by the visibility of the construction activities, namely tall cranes and other large-scale equipment. Towards the end of the construction phase, impacts on landscape character will arise from the visibility of permanent large-scale structures as these near completion. The views from most of the Wooded Inland Landscape Unit will be unaffected due to the dense wooded cover, which will visually screen the construction activities.

Taking into account the limited areas of this landscape relative to the Afungi Peninsula that will be affected and the temporary nature of the construction works, a Low magnitude of change will arise to this landscape of Low sensitivity, thereby resulting in an impact on the character of this landscape considered to be NEGLIGIBLE.

Operations

Some impacts to the character of this landscape Unit will arise as a result of the visibility of the Onshore Project infrastructure. The ZTVs illustrated in *Figure 12.14* to *Figure 12.17* show the extent of theoretical visibility of various large structures of the Onshore and Near Shore Project. In reality, the vegetation will visually screen much of the Project from many inland locations. Therefore, visibility will likely be much less than that illustrated; however, isolated elevated locations will likely provide views of taller elements.

The visual impact of the Project on this landscape will be limited to isolated elevated locations with views overlooking Palma Bay and Afungi Peninsula. These include short sections of the road Route No. 25 (south of Palma) and short sections of the road Route No. 13 (north of Palma). The main elements of the Onshore Project that will be visible from these locations will include the taller structures, such as the flare stack and the upper sections of the LNG tanks. The Near Shore Project infrastructure and arriving/departing LNG Carriers may also be partly visible from this landscape area, and air traffic will be seen as an occasional occurrence.

Taking into account the limited areas of this inland landscape that will be affected by the Project, a Low magnitude impact is anticipated. Considering the Low sensitivity of the Unit, the resulting impact is considered to be of NEGLIGIBLE significance on the character of this landscape area.

12.5.6 Impacts of the Project on the Quionga to Cabo Delgado Seascape Unit

Overview

The Quionga to Cabo Delgado Seascape Unit lies to the north of Palma Bay and features abundant mature mangrove vegetation, especially in the north near Quionga. The Project will be largely visually screened from this area. The potential for this Seascape Unit to be affected by the Project is limited,

therefore it has a Low sensitivity to the proposed visual changes associated with the Project.

Construction

Portions of the Quionga to Cabo Delgado Seascape Unit will be affected by the visibility of vessels associated with the construction of the Offshore Project, in particular vessels involved in the installation of the gas pipelines and Subsea Production System. These activities will be partly visible from the tip of Cabo Delgado Peninsula. This location will also provide a view of construction activities associated with the development of the Near Shore and Onshore Project infrastructure.

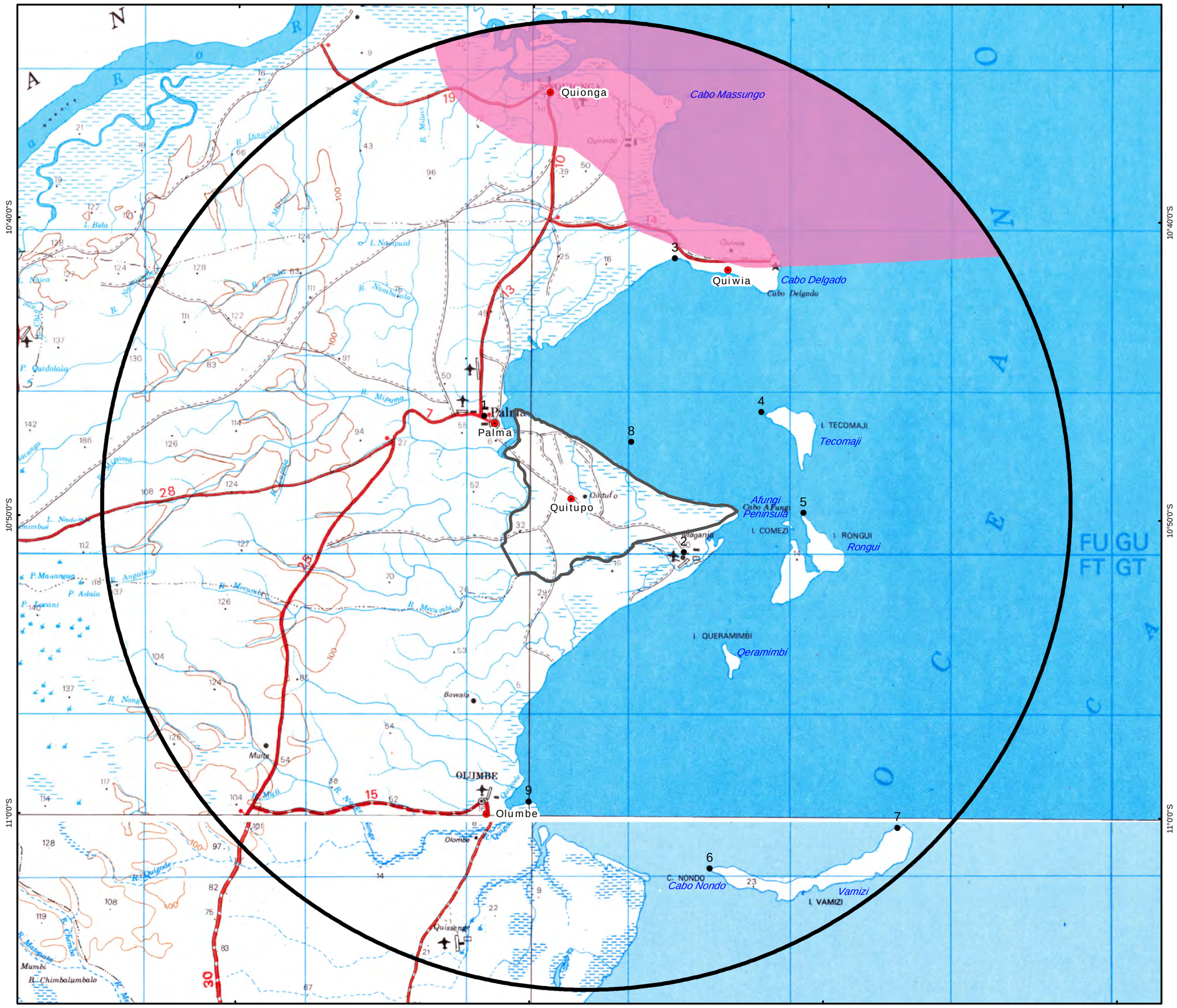
The activities associated with the Near Shore and Onshore Project will be located at least 12km away from this Seascape Unit. Taking into account the distance and temporary nature of these construction works, a Low magnitude of change will arise to this Seascape Unit, of Low sensitivity, resulting in a NEGLIGIBLE impact.

Operations

The results of the ZTVs illustrated in *Figure 12.14* to *Figure 12.17* indicate that a part of the Quionga to Cabo Delgado Seascape Unit extending from Cabo Massungo southwards to Cabo Delgado will be affected theoretically by the Project during the operational phase. However, the Cabo Delgado Peninsula will screen the view of the Project from most of this seascape, so the majority of this area will not be affected. Therefore, visual impacts will be largely limited to the end of Cabo Delgado Peninsula. Visibility of the Near Shore Project will be influenced by weather conditions, and will likely render the Project invisible during rainy conditions or faintly visible during clear conditions.

The coastline and sea areas further north of Cabo Delgado Peninsula may be affected by the visibility of the flare stack and the LNG Carriers, as well as of air traffic.

Taking into account the limited areas of this Seascape Unit that will be affected by the Project, a Low magnitude of change is expected to this Seascape Unit, which is of Low sensitivity, thereby resulting in a NEGLIGIBLE impact on this Unit.



Legend

- Afungi Project Site
- 30km Buffer Study Area

Seascape Character Units

- Quionga to Cabo Delgado Seascape Unit

Viewpoints for Visual Impact Assessment

1. Palma
2. Maganja
3. Quiwia
4. Tecomaji
5. Rongui
6. Vamisi west
7. Vamisi east
8. Location at sea within Palma Bay
9. Olumbe

SCALE:

0 5 10
Kilometers

N

TITLE:

Figure 12.20: Quionga to Cabo Delgado Seascape Unit

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: EO	PROJECT: 0133576
DRAWN: AB	APPROVED: EO	SCALE: 1 : 225 000

DRAWING: Quionga to Cabo Delgado Seascape Unit.mxd

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12.5.7 Impacts of the Project on the Afungi Peninsula to Cabo Nondo Seascape Unit

Overview

The Afungi Peninsula to Cabo Nondo Seascape Unit includes the southern portion of Afungi Peninsula, extending from the settlement of Olumbe east to Cabo Nondo (see *Figure 12.21)*. The existing vegetation and natural shape of the coastline limits the potential for visual impacts to much of this Unit. In the vicinity of Olumbe, extensive mature vegetation will visually separate this part of the Seascape Unit from the Onshore Project. However, parts of this Seascape Unit will overlook the Afungi Project Site, including the tip of Afungi Peninsula and the islands of Rongui, Queramimbi and Vamizi.

Taking all of the above characteristics into account, this Seascape Unit is considered to have a Medium sensitivity to the proposed visual change brought on by the Project.

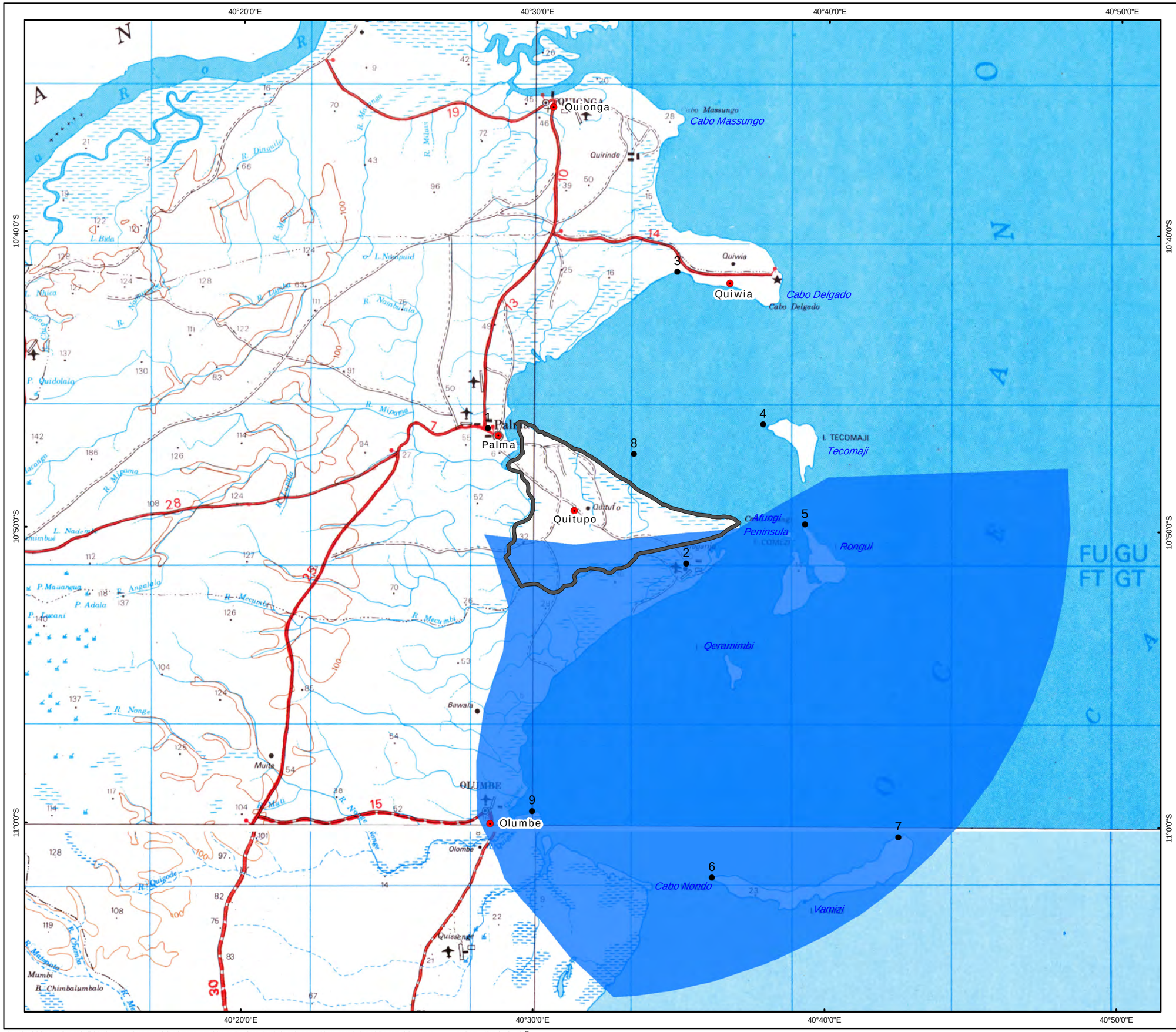
Construction

During construction, the northern part of the Afungi Peninsula to Cabo Nondo Seascape Unit will be affected by the visibility of the construction works associated with the Onshore, Near Shore and Offshore Project. Areas immediately south of the Afungi Project Site, as well as the tip of Afungi Peninsula and portions of the western shore of Rongui Island, will be affected by the visibility of the Onshore and Near Shore construction activities. These visual impacts will be mainly confined to the view of tall construction equipment such as cranes. Other parts of the coastline and seaward components of this Unit will be affected by the visibility of the vessels associated with the construction of the Offshore Project components (ie development drilling, installation of the Subsea Production System and pipe laying).

Taking into account the temporary nature of these construction works and the limited area of this seascape that will be affected by the construction activities, a Low magnitude of change will arise to this Seascape Unit, of Medium sensitivity, resulting in an impact significance of MINOR.

Operations

The ZTVs illustrated in *Figure 12.14* to *Figure 12.17* indicate that much of the coastline and seascape associated with this area will be affected by the visibility of the Onshore and Near Shore Project infrastructure. However, the existing vegetation will likely screen all but the taller components of the Project. This Unit will therefore be affected primarily in locations where vegetation is sparse or absent. However, the upper portions of the taller Project infrastructure will likely be visible above the vegetation.



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Further south along the coastline, the vegetation is more dense and is expected largely to screen the Project from view. As an example, the coastline at Olumbe and the surrounding area will be unaffected due to the presence of mature mangroves, which will visually screen the Project.

The islands of Vamizi, Rongui and Queramimbi are densely vegetated and therefore visual impacts will be limited to the northern coastline of these islands. The Near Shore Project will be clearly visible, albeit at some distance (6km approximately) from the western shore of Rongui Island. Both Vamizi and Queramimbi may be affected by the visibility of the taller elements of the Project (eg flare and LNG storage tanks), which may extend above the line of existing vegetation of Afungi Peninsula.

The coastline of these islands will be affected by the visibility of passing LNG Carriers and Project vessels. Offshore drill rigs may also be visible due to the associated lighting or intermittent flaring.

Taking into account the extent of this Unit that will be affected by the Project, a Medium magnitude impact is anticipated. The Afungi Peninsula to Cabo Nondo Seascape Unit is considered to be of Medium sensitivity, therefore the resulting impact is considered to be of MODERATE significance.

12.5.8 Impacts on Visual Amenity from Fixed Viewpoint Locations

Overview

The introduction of new structures and activity within the Afungi Project Site will have impacts on the quality of views experienced by people living, working or visiting in the surrounding area. The LNG Facility and associated infrastructure will be seen during construction and operations from fixed locations and as people move through the area.

Nine viewpoints were identified in the baseline for this assessment (*Figure 12.13*). These viewpoints have been evaluated in terms of sensitivity to the proposed change.

Local residents are judged to have a generally High level of sensitivity to the type of visual changes introduced by the Project. Residents that live within the coastal settlements of Palma and Quiwia and along the coast between these settlements are likely to have views of the Project.

Those travelling to or through the Afungi Project Site, both on land and at sea, are considered to have a Medium to Low level of sensitivity to the proposed change. This sensitivity depends upon the purpose and objective of the traveller, and takes into account the transitory nature of views in any one direction.

Tourists and recreational users are attracted to the area by the amenities provided by the environment of the coastline and islands within the vicinity.

Tourists and recreational users will have different objectives and differing levels of sensitivity to any change in the characteristics of the landscape or seascape. The sensitivity of this group is usually considered to be High. Tourism is recognised as an important element in the local and regional economy. People in this group include tourism operators on Vamizi and Tecomaji islands.

Local (non-Project) workers are generally less sensitive to effects, as they are focused on the tasks they are carrying out. Outdoor workers associated with farming fishing and shipping are also considered to have a Low sensitivity to the proposed change.

Construction

During the construction phase, viewers in the surrounding area will clearly see the construction activities, especially large machinery, vessels and large structures such as LNG storage tanks being erected. Viewers located near to the Afungi Project Site will experience a considerable change in their view, with the ongoing construction being visually dominant elements. The visual impact of the construction works on receptors at the nine viewpoints is discussed in *Table 12.16* below. Whilst the visual change from certain viewpoints is considerable, the magnitude of change is generally lower than that discussed for the operational phase (detailed in *Table 12.17*). This is because of the short-term duration of the construction phase.

Table 12.16 Visual Impact at Selected Viewpoints during Construction

Viewpoint No.	Description of Viewpoint	Viewer Type	Description of Existing View	Viewpoint Sensitivity	Magnitude of Change	Visual Impact Significance
1	Palma (town centre)	Residents of Palma	The upper portions of the taller construction equipment associated with the Onshore Project will be clearly visible from Palma, above the line of existing vegetation. Construction works associated with the Near Shore Project will be visible, as these protrude out to sea. Construction activities associated with the installation of the pipelines/Subsea Production System may be visible from Palma, depending on weather conditions.	High	Low	MINOR to MODERATE
2	Maganja	Residents of Maganja.	Most of the construction activities will be visually screened by mature wooded vegetation. Some of the taller cranes and machinery may be partly visible from Maganja.	High	Low	MINOR to MODERATE
3	Quiwia and adjacent beach	Residents of Quiwia Users of the beach	The construction activities associated with the Near Shore and Offshore Project will be visible in the distance from Quiwia. These activities are associated with the installation of the Near Shore Project infrastructure (Pioneer Dock, LNG Export Jetty and MPD), and the installation of the pipelines/Subsea Production System. Visibility will depend on weather conditions.	High	Low	MINOR to MODERATE
4	Tecomaji Island	Tourist users of the beach	Viewers will clearly see the construction works associated with the installation of the pipelines/Subsea Production System, as this is routed between the islands of Tecomaji and Rongui. Further towards the coast, the cranes and machinery associated with the Near Shore Project components will be visible.	High	Low	MINOR to MODERATE
5	Rongui Island	Tourist users of the beach	Viewers will clearly see the construction works associated with the installation of the pipelines/Subsea Production System, as this is routed between the islands of Tecomaji and Rongui. Further towards the coast, the cranes and machinery associated with the Near Shore project components will be visible.	High	Low	MINOR to MODERATE
6	Vamizi Island (beach on north western tip)	Tourist users of the beach and tourism operators	Viewers may see the construction works in the distance, specifically the works and vessels associated with the Offshore Project, including the installation of pipelines/Subsea Production System.	High	Negligible to Low	NEGLIGIBLE

Viewpoint No.	Description of Viewpoint	Viewer Type	Description of Existing View	Viewpoint Sensitivity	Magnitude of Change	Visual Impact Significance
7	Vamizi Island (beach on north eastern tip)	Tourist users of the beach and tourism operators	Viewers may see the construction works in the distance, specifically the works and vessels associated with the Offshore Project, including the installation of pipelines/Subsea Production System.	High	Negligible to Low	NEGLIGIBLE
8	Location at sea within Palma Bay	Tourists on boats Working fishermen at sea	Viewers at this location will clearly see the construction activities associated with the Onshore, Near Shore and Offshore Project.	High Medium	Medium	MODERATE
9	Olumbe	Residents of Olumbe at or near the beach	The Onshore and Near Shore Project construction activities will not be visible from this location. Existing extensive mature mangrove vegetation protruding out to sea will visually screen this settlement from the Project. The vessels involved in construction and laying of the pipelines/subsea infrastructure may be visible.	High	Negligible	NEGLIGIBLE

Key:

Viewer sensitivity: Low, Medium, High.
Magnitude of change: Negligible, Low, Medium, High.
Significance of impact: NEGLIGIBLE, MINOR, MODERATE, MAJOR.

Operations

The Afungi Project Site is surrounded by woodland and shrub vegetation, which will screen much of the Project from view. The Project will, however, be visible from elevated areas overlooking Palma Bay and the Afungi Peninsula. In most cases, only the upper portions of the taller elements of the Project will be visible above the line of existing vegetation from various locations inland, including the following:

- eastern edge of Palma;
- isolated elevated locations on road Route No. 13 (affecting viewers travelling in a southerly direction only);
- isolated elevated locations on road Route No. 25 (affecting viewers travelling in a northerly direction only);
- isolated elevated locations on road Route No. 28 (affecting viewers travelling in a westerly direction only);
- beach along the northern shore of Afungi Peninsula;
- beach along the northern side of Palma Bay, including Quiwia;
- eastern tip of Afungi Peninsula; and
- eastern tip of Cabo Delgado Peninsula.

Viewers located at sea and on west-facing beaches of Rongui and Tecomaji islands will have clear unobstructed views of the Near Shore infrastructure, as shown in *Figure 12.17*. Some of the larger structures associated with the Onshore Project may also be partly visible from Rongui and Tecomaji islands under clear weather conditions with optimal visibility. Under these conditions, the taller structures of the Project may be slightly visible from Vamizi Island, as shown in *Figure 12.17*.

The visual impact of the LNG Facility and associated infrastructure on receptors at each of the representative viewpoints during the operational phase is outlined in *Table 12.17*.

The assessment was assisted by the preparation of photomontages of the LNG Facility from the five viewpoint locations discussed in *Table 12.17*. These locations were selected to illustrate the appearance of the Onshore Project from locations at varying distances. These images are presented in *Figure 12.22* to *Figure 12.32,* alongside baseline photographs. These figures do not provide an exact replication of future views, but the structures are shown to scale to give an idea of the extent of the visual change. In assessing the visual

impact in each case, consideration is also given to the effect of light and weather conditions on visibility.

Figure 12.22 Existing View at Viewpoint 1 Palma

Grid Reference:	661050 E 8808311 N		CLIENT:	SIZE: A3
Distance to site:	5.9Km			
Direction from site:	NW		ERM	Figure Existing view at Viewpoint 1 Palma
View point level:	47.2m			DATE: 1/8/12 | CHECKED: EOC | PROJECT:
Photo taken:	29/1/12			DRAWN: TMD | APPROVED: EOC | LNG Mozambique
Horizontal field of view:	51°			DRAWING: | REV: 0
Viewing distance approx:	45cm for A3 print			
Perspective	Cylindrical			

Figure 12.23 Proposed View at Viewpoint 1 Palma

Grid Reference:	661050 E 8808311 N	Operations housing, Construction laydown / staging, Pipeline inlet gas, Operations support & Construction support facility areas shown as 15m high blocks	CLIENT:
Distance to site:	5.9Km		SIZE: A3
Direction from site:	NW		ERM
View point level:	47.2m		Figure Proposed view at Viewpoint 1 Palma
Photo taken:	29/1/12		DATE: 1/8/12 CHECKED: EOC PROJECT:
Horizontal field of view:	51°		DRAWN: TMD APPROVED: EOC LNG Mozambique
Viewing distance approx:	45cm for A3 print		DRAWING: REV: 0
Perspective	Cylindrical		

Figure 12.24 Existing View at Viewpoint 3 Quiwia

Grid Reference:	672842 E 8818063 N	CLIENT:	SIZE: A3
Distance to site:	9.4Km		Figure Existing view at Viewpoint 3 Quiwia
Direction from site:	NNE		
View point level:	6.0m	ERM	
Photo taken:	29/1/12	DATE: 1/8/12 CHECKED: EOC	PROJECT:
Horizontal field of view:	51°	DRAWN: TMD APPROVED: EOC	LNG Mozambique
Viewing distance approx:	45cm for A3 print	DRAWING:	REV: 0
Perspective	Cylindrical		

Figure 12.25 Proposed View at Viewpoint 3 Quiwia

Grid Reference:	672842 E 8818063 N
Distance to site:	9.4Km
Direction from site:	NNE
View point level:	6.0m
Photo taken:	29/1/12
Horizontal field of view:	51°
Viewing distance approx:	45cm for A3 print
Perspective	Cylindrical

CLIENT:

SIZE: A3

ERM

Figure
Proposed view at Viewpoint 3 Quiwia

DATE: 1/8/12	CHECKED: EOC	PROJECT:
DRAWN: TMD	APPROVED: EOC	LNG Mozambique
DRAWING:		REV: 0

Figure 12.26 Existing View at Viewpoint 4 Tecomaji

Grid Reference:	678204 E 8808547 N		CLIENT:	SIZE: A3
Distance to site:	7.0Km			
Direction from site:	NE			
View point level:	8.7m			
Photo taken:	28/1/12			
Horizontal field of view:	51°			
Viewing distance approx:	45cm for A3 print			
Perspective	Cylindrical			

ERM

Figure
Existing view at Viewpoint 4
Tecomaji

DATE: 1/8/12	CHECKED: EOC	PROJECT:
DRAWN: TMD	APPROVED: EOC	LNG Mozambique
DRAWING:		REV: 0

Figure 12.27 Proposed View at Viewpoint 4 Tecomaji

Grid Reference:	678204 E 8808547 N	Operations housing, Construction laydown / staging, Pipeline inlet gas, Operations support & Construction support facility areas shown as 15m high blocks	CLIENT:
Distance to site:	7.0Km		SIZE: A3
Direction from site:	NE		ERM
View point level:	8.7m		Figure: Proposed view at Viewpoint 4 Tecomaji
Photo taken:	28/1/12		DATE: 1/8/12 | CHECKED: EOC | PROJECT:
Horizontal field of view:	51°		DRAWN: TMD | APPROVED: EOC | LNG Mozambique
Viewing distance approx:	45cm for A3 print		DRAWING: | REV: 0
Perspective	Cylindrical		

Figure 12.28 Existing and Proposed View at Viewpoint 4 Tecomaji

Grid Reference:	678204 E 8808547 N
Distance to site:	7.0Km
Direction from site:	NE
View point level:	8.7m
Photo taken:	28/1/12
Horizontal field of view:	76°
Viewing distance approx:	30cm for A3 print
Perspective	Cylindrical

CLIENT:

SIZE: A3

ERM

Figure
Proposed view at Viewpoint 4 Tecomaji

DATE: 1/8/12	CHECKED: EOC	PROJECT:
DRAWN: TMD	APPROVED: EOC	LNG Mozambique
DRAWING:		REV: 0

Figure 12.29 Existing View at Viewpoint 5 Rongui

Grid Reference:	680806 E 8802315 N		CLIENT:	SIZE: A3
Distance to site:	6.4Km			
Direction from site:	E			
View point level:	7.6m			
Photo taken:	28/1/12		ERM	Figure Existing view at Viewpoint 5 Rongui
Horizontal field of view:	51°			
Viewing distance approx:	45cm for A3 print			DATE: 1/8/12 | CHECKED: EOC | PROJECT:
Perspective	Cylindrical			DRAWN: TMD | APPROVED: EOC | LNG Mozambique
				DRAWING: | REV: 0

Figure 12.30 Proposed View at Viewpoint 5 Rongui

Grid Reference:	680806 E 8802315 N
Distance to site:	6.4Km
Direction from site:	E
View point level:	7.6m
Photo taken:	28/1/12
Horizontal field of view:	51°
Viewing distance approx:	45cm for A3 print
Perspective	Cylindrical

CLIENT:

SIZE: A3

ERM

Figure
Proposed view at Viewpoint 5 Rongui

DATE: 1/8/12	CHECKED: EOC	PROJECT:
DRAWN: TMD	APPROVED: EOC	LNG Mozambique
DRAWING:		REV: 0

Figure 12.31 Existing View at Viewpoint 6 West Tip of Vamizi

Grid Reference:	674509 E 8780805 N	CLIENT:	SIZE: A3
Distance to site:	20.0Km		Figure
Direction from site:	S		Existing view at Viewpoint 6
View point level:	4.4m		West tip of Vamisi
Photo taken:	28/1/12	ERM	DATE: 1/8/12 CHECKED: EOC PROJECT:
Horizontal field of view:	51°		DRAWN: TMD APPROVED: EOC LNG Mozambique
Viewing distance approx:	45cm for A3 print		DRAWING: REV: 0
Perspective	Cylindrical		

Figure 12.32 Proposed View at Viewpoint 6 West Tip of Vamizi

Grid Reference:	674509 E 8780805 N	Operations housing, Construction laydown / staging, Pipeline inlet gas, Operations support & Construction support facility areas shown as 15m high blocks
Distance to site:	20.0Km	
Direction from site:	S	
View point level:	4.4m	
Photo taken:	28/1/12	
Horizontal field of view:	51°	
Viewing distance approx:	45cm for A3 print	
Perspective	Cylindrical	

CLIENT:

SIZE: A3

ERM

Figure
Proposed view at Viewpoint 6
West tip of Vamisi

DATE: 1/8/12	CHECKED: EOC	PROJECT:
DRAWN: TMD	APPROVED: EOC	LNG Mozambique
DRAWING:		REV: 0

At Viewpoint 1, Palma residents will experience a change in the view towards Palma Bay and Afungi Peninsula during the operational phase. The Onshore Project components will be clearly visible but partly screened by vegetation, as shown in *Figure 12.23*. The addition of the Near Shore Project infrastructure and the presence of LNG Carriers and Project vessels will alter the appearance of Palma Bay. The visual change will comprise a notable industrial development introduced into an essentially rural seascape. The magnitude of change is considered to be Medium.

At Viewpoint 2, residents in Maganja will continue to experience the existing view dominated by woody vegetation, albeit with views of upper portions of taller structures. Although the viewer is located close to the Onshore Project, only the upper portions of the taller elements of the Project (flare stack and airport control tower) are likely to be visible, as indicated in *Figure 12.14* and *Figure 12.16*. A Medium magnitude of change is predicted.

At Viewpoint 3, residents in Quiwia will be located at least 10km away from the Near Shore Project. However, the infrastructure will be clearly visible as a small element in the distance, as shown in *Figure 12.25*, and will likely be invisible during adverse weather conditions. Similarly, the LNG Carriers and escort tugs will be visible in the distance. The distance from the Project results in a small magnitude of change predicted for Viewpoint 3.

At Viewpoint 4, recreational users of the beach on the western shoreline of Tecomaji Island will see the Near Shore Project during weather conditions that afford clear visibility. The Near Shore Project infrastructure and some of the taller element of the Onshore Project will be visible in the background, as shown in *Figure 12.27*. Viewpoint 4 may also provide a view of LNG Carriers and Project vessels en route to or from Palma Bay. A Medium magnitude of change is predicted due to the distance from the Project (approximately 7km).

At Viewpoint 5, recreational users of the beach at Rongui Island will see the Near Shore Project located at least 11km away. The MPD will be visible in the foreground, with the LNG Export Jetty and Future Jetty (when built) behind, as shown in *Figure 12.30*. This visual change is reflected in the Medium magnitude of change predicted for this viewpoint.

At Viewpoints 6 and 7, the recreational users of the beach on the northern shoreline of Vamizi Island will be located approximately 20km away from the Project. A view of the Project from Viewpoint 6 is shown in *Figure 12.32*. Limitations on visibility due to distance, weather and visual screening provided by Afungi Peninsula in the foreground result in a magnitude of change that will be either Low (during clear weather conditions) or Negligible (during poor visibility weather conditions).

Sea-based viewers such as fishermen at Viewpoint 8, located north of Afungi Peninsula in Palma Bay, will be located very close to the Project and will see the Onshore and Near Shore Project infrastructure at very short range. The character of the seascape will appear dramatically altered from Viewpoint 8;

therefore, a High magnitude of visual change is expected. However, given that there will be exclusion zones around the Near Shore Project infrastructure, it is unlikely that receptors will be able to view the Project from this location.

At Viewpoint 9 in Olumbe, the Project will be screened from view by dense vegetation. At sea, LNG Carriers and Project vessels may be seen as they enter and depart Palma Bay; however, these vessels will likely appear as small or negligible elements, depending on the weather conditions. Therefore, a Negligible magnitude of change is predicted for Viewpoint 9.

In the case of all Viewpoints, Project-related aircraft will be visible for short periods of time for the duration of the Project. Non Project-related aircrafts are commonly seen from these Viewpoints; however, the size of the Project aircrafts (such as the Antonov 124) may alter the viewer's perception of the area by making it seem less rural or more developed. Therefore, Project-related aircraft may be seen as contributing to visual impact on all Viewpoints.

The assessment provided in *Table 12.17* indicates that there will be visual impacts of MODERATE to MAJOR significance at three of the Viewpoints. MAJOR visual impacts will be confined to Viewpoint locations adjacent to or very near to the Onshore and Near Shore Project.

Table 12.17 Visual Impact at Selected Viewpoints during Operations

Viewpoint No.	Description of Viewpoint	Photomontage	Viewer Type	Description of Existing View	Viewpoint Sensitivity	Magnitude of Change	Visual Impact Significance
1	Palma (town centre)	*Figure 12.23*	Residents of Palma	The upper portions of the taller structures of the Onshore Project will be clearly visible above the line of existing vegetation. These include the flare stack and the upper portions of the LNG storage tanks. The Near Shore Project infrastructure may be visible, as these protrude out to sea. Intermittent views of the LNG Carriers, escort tugs and maintenance vessels arriving or departing Palma Bay will be visible in the distance.	High	Medium	MODERATE to MAJOR
2	Maganja	None	Residents of Maganja	Some of the upper portions of taller elements of the Project will be clearly visible above the line of existing vegetation. Most of the Project will be visually screened by mature wooded vegetation.	High	Medium	MODERATE to MAJOR
3	Quiwia and adjacent beach	*Figure 12.25*	Residents of Quiwia Users of the beach	The larger infrastructure associated with the Onshore Project (LNG storage tanks, Trains and flare stack) will be visible in the distance. The Near Shore Project infrastructure will also be visible. Visibility will vary with weather conditions. During weather conditions that afford clear long-distance views, the Project will appear as a small to medium-sized development. LNG Carriers, escort tugs and maintenance vessels will be seen entering and leaving Palma Bay on an intermittent basis.	High	Low to Medium	MINOR to MODERATE
4	Tecomaji Island	*Figure 12.27*	Tourist users of the beach	The Onshore Project, including the flare stack, LNG storage tanks and LNG Trains, will be clearly visible. The Near Shore Project infrastructure, including the LNG Export Jetty and MPD, will be visible. The passing LNG Carriers, escort tugs and maintenance vessels will be clearly visible at short range, where these travel close to the island.	High	Medium	MODERATE
5	Rongui Island	*Figure 12.30*	Tourist users of the beach	The Onshore Project infrastructure (LNG storage tanks, Trains and flare stack) will be clearly visible. The Near Shore Project infrastructure, including the LNG Export Jetty and MPD, will be clearly visible, as these protrude out to sea. LNG Carriers will be visible while berthed at the Export Jetty and in transit.	High	Medium	MODERATE

Viewpoint No.	Description of Viewpoint	Photomontage	Viewer Type	Description of Existing View	Viewpoint Sensitivity	Magnitude of Change	Visual Impact Significance
6	Vamizi Island (beach on north western tip)	*Figure 12.32*	Tourist users of the beach	The upper portions of the taller structures of the Onshore Project may be faintly visible above the line of existing vegetation. These include the flare stack, LNG storage tanks and Trains. LNG Carriers, escort tugs and maintenance vessels will be visible in the distance as they move in and out of Palma Bay. Visibility of the Project will vary, depending on weather conditions.	High	Negligible to Low	NEGLIGIBLE to MINOR
7	Vamizi Island (beach on north eastern tip)	Similar to viewpoint 6.	Tourist users of the beach	A similar view will be available from this location as recorded for Viewpoint 6 Vamizi, western tip.	High	Negligible to Low	NEGLIGIBLE to MINOR
8	Location at sea within Palma Bay	None	Tourists on boats Working fishermen at sea	Viewers at this location will clearly see the Onshore and Near Shore Project infrastructure. The LNG Carriers will be clearly visible berthed at the LNG Export Jetty or en route, entering or leaving Palma Bay. However, exclusion zones around the Near Shore Project infrastructure will likely prevent access to this Viewpoint.	High Medium	High	MODERATE to MAJOR
9	Olumbe	None	Residents of Olumbe at or near the beach	The LNG Facility will not be visible from this location. Existing extensive mature mangrove vegetation will visually screen this Viewpoint from the Project. Views may be available of the LNG Carriers beyond Tecomaji Island as they approach or leave Palma Bay.	High	Negligible	NEGLIGIBLE

Key:

Viewer sensitivity: Low, Medium, High.
Magnitude of change: Low, Medium, High, Negligible.
Significance of impact: NEGLIGIBLE, MINOR, MODERATE, MAJOR.

12.6 SOILS

12.6.1 Overview

This section identifies potential impacts to soil resources and the subsequent effects on land capability.

12.6.2 Impact of Site Clearance on Land Capability

Impact Assessment

Activities associated with the construction phase of the Project could lead to the following impacts on soils:

- soil compaction and topsoil loss;
- water and wind soil erosion (and sediment release to land and water); and
- alteration of natural drainage.

An area of approximately 3,600ha will be cleared of vegetation to ground level and demined. Once demining activities are complete, earthworks will commence. Topsoil will be stripped to a depth of 30cm within the Project Footprint Area and stockpiled for future use in rehabilitation and revegetation. The Project Footprint Area will be graded and levelled, and cut and fill operations will be managed such that there will be minimal excess spoil. Compaction and increased erosion from increased exposure to wind and water are likely to cause changes in the soil structure and degradation of soil quality. The extent to which these occur will be dependent on the properties of the soils.

Vegetation cover is the most important physical factor protecting soil from erosion by water and wind. The sandy soils within the Afungi Project Site will be particularly vulnerable to wind erosion once the vegetation is cleared and the topsoil is removed during site clearance and stockpiling. An intact cover reduces impact from raindrops on the soil, slows down surface run-off, filters sediment and binds the soil together for more stability.

Intensity of potential erosion is also influenced by precipitation, which is generally high in this region. Erosion may come about when stormwater run-off comes into contact with bare soil patches, especially on sloped terrain or running down inefficiently sloped stockpiles. Heavy rainstorms during the monsoon can initiate erosion, on even a slightly elevated area of exposed soil. The impact of erosion through water run-off will play a significant role in the wetland soil units (W-Units), potentially increasing sediment to wetlands.

The compaction of the subsoils through site grading and levelling, and the presence of heavy vehicles and machinery during construction, will result in lower permeability of the soil and therefore decrease infiltration and increase run-off, altering the natural drainage characteristics of the soil. Without appropriate measures, run-off from hardstanding areas (roads and the Project

Footprint Area), in addition to exposure to wind, may increase erosion. If heavy vehicles and machinery are not confined to the working areas, widespread erosion may take place. Land capability and productivity will be lost within the Project Footprint Area from the change to industrial use.

The impacts of compaction and erosion of soils will be negative and restricted to onsite. Outside of the Project Footprint Area, potential limited impacts may be associated with erosion along access roads. Many of the impacts to soil and land capability cannot be mitigated further, because they derive from the physical land-take footprint of the development. However, measures can be implemented to help minimise impacts. Impacts will definitely occur during construction, and will be permanent in duration. Intensity will range from Low to High, as natural functions of the soil will be altered to varying degrees. Impact magnitude will be Low to Medium. Impact significance to soil resources and land capability pre-mitigation is expected to be MODERATE.

The degree of confidence in the assessment is High.

Mitigation Measures

The Project will develop and implement a Soils, Erosion Control and Reinstatement Plan, which will inter alia address the following mitigation measures:

- Restrict extent of disturbance within the Afungi Project Site to the extent practicable.

- Minimise the period of exposure of soil surface, including stockpiles, by revegetating temporary-use areas as soon as practicable after construction activities.

- Use dust suppression measures (eg wetting the ground) when necessary to reduce wind erosion.

- Stockpiled soil is not to be compacted.

- Stockpiles are to be protected from erosion by stormwater.

Residual Impact

With the implementation of the above mitigation measures, impact significance is likely to be reduced to MINOR. This is due to the magnitude of the impact being reduced to Low.

Table 12.18 Impact of Site Clearance on Land Capability

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Permanent	Permanent
Extent	Onsite	Onsite
Intensity	Low to High	Low to Medium
Magnitude	**Medium**	**Low**
Likelihood	**Definite**	**Definite**
Significance	**MODERATE**	**MINOR**

12.6.3 Impact of Accidental Spills and Leaks of Fuel or Oil on Soil

This impact assessment addresses minor spills and leaks that tend to occur on any project site during normal activities. Spills resulting from leaks or rupture of storage tanks are addressed in *Chapter 14* (Unplanned Events) and not discussed in this section.

Impact Assessment

Impacts to soil resources are dependent on the size of a spill or leak and the speed with which it is addressed and cleaned up. If impacted, the ability of soil to carry out its functions can be compromised, thus affecting the land capability of the soil. In the event of a spill or leak, the constituents could rapidly infiltrate into sand and present a risk of groundwater impact, which is addressed further in *Section 12.8*.

The potential for impact to soil resources exists primarily during the site preparation and construction phases. Such impacts could result from spills or leaks of fuels, oils, lubricants and other chemicals from construction machinery and vehicles. Given that most minor spills and leaks would occur in the construction work areas, the intensity of the impact is expected to be Low. The extent will be onsite, with a short to medium-term effect. The overall magnitude would be Low; however, with a Likely probability of occurrence. The intensity of the impact on soil resources is dependent on the existing land use of the area affected by the spill, and may be Medium. Therefore, the significance is expected to be MINOR for the construction and operational phases of the Project. The degree of confidence in the assessment is High.

Soil impacts will be greatly reduced during the operational phase since large-scale use of mobile construction equipment will be reduced; additionally, the process areas susceptible to possible leakage will be paved. To reduce the likelihood of soil impacts resulting from spills or leaks during the operational phase, a stormwater treatment system will be in place. This treatment system will be designed to capture potentially impacted stormwater and washwater from 'dirty' areas for treatment before reuse or discharge. The stormwater collection and treatment system will minimise or eliminate the risk of soil impacts within or around the LNG Process Area.

Mitigation Measures

The Project's Pollution and Hazardous Materials Management Plan and Emergency Response Plan will address spill prevention, clean up and response and inter alia address the following mitigation measures:

- Construction and operations vehicles and equipment will be serviced and maintained regularly to prevent incidental leaks.
- Construction and operations vehicles should remain on roads and designated working areas.
- Spill containment and clean-up kits will be available onsite. Clean-up will occur as soon as possible after the spill. If required, impacted soil will be removed and disposed of appropriately.
- Fuels, lubricants, hydrocarbon liquids and other chemical storage onsite will be secured by bunded facilities.

Residual Impact

Based upon the above mitigation measures and procedures that will be put in place to prevent, contain, clean up and dispose of any spillage, significant effects to soil resources are unlikely to arise. Impacts are expected to be of Low magnitude, should they occur, and of NEGLIGIBLE significance during all phases of the Project.

Table 12.19 Impact of Accidental Spills and Leaks of Fuel or Oil on Soils

	Without Mitigation	**Residual Impact (with Mitigation)**
Construction Phase		
Duration	Short term to medium term	Short term
Extent	Onsite	Onsite
Intensity	Low	Negligible
Magnitude	**Low**	**Negligible**
Likelihood	**Likely**	**Likely**
Significance	**MINOR**	**NEGLIGIBLE**
Operational Phase		
Duration	Short term to medium term	Short term
Extent	Onsite	Onsite
Intensity	Low	Negligible
Magnitude	**Low**	**Negligible**
Likelihood	**Likely**	**Likely**
Significance	**MINOR**	**NEGLIGIBLE**

12.7 HYDROLOGY

The construction of the Project is likely to alter the hydrology of the Afungi Project Site. Such alterations have the potential to impact the flora and fauna of the area adversely. These potential impacts are assessed in the following

sections; therefore, a detailed assessment of impacts to hydrology is not provided as a separate section.

12.8 GROUNDWATER

12.8.1 Overview

Groundwater demand for domestic use that needs to be supplied by borehole water is between 80 and 600m^3/d. Conservatively, the the peak demand of 600m^3/d is anticipated from Year 2 of the Project, up to 12 months. Thereafter a desalination plant will be operational and will supplement groundwater supply for domestic use (see *Chapter 4*). The main potential groundwater impacts of the proposed Project are related to following activities:

- Over-abstraction of water supply wells;
- Surface sealing in the vicinity of the LNG Processing Area resulting in more surface water runoff and reduced infiltration to recharge groundwater; and
- In-filling of Catchment B in the LNG Processing Area resulting in changes to the extent of the groundwater discharge area, and subsequent groundwater level rise and potentially flooding.

The approach and methodology for the groundwater modelling undertaken, and the various scenarios modelled are provided in *Annex C*. Detailed modelling results are found in *Annex G*. The sections below provide a summary of the conclusions drawn from the modelling results and a description of the potential impacts the Project may have on groundwater resource and on receptors (eg shallow groundwater used by community wells) and resources (and surface water bodies such as wetlands, mangroves, estuaries and streams) dependent on groundwater.

12.8.2 Groundwater Modelling Results

A number of scenarios were modelled to understand maximum pumping rates and maximum available drawdown to avoid saline intrusion; to determine whether the aquifer can sustain the Project water demand (domestic); to investigate the impact of reduced recharge from surface sealing within the LNG Processing Area as well as the effects of in-filling Catchment B. These scenarios are detailed in the groundwater modelling methodology in *Annex C*. This section provides a summary of the key findings pertinent to the impact assessment.

Recommended Maximum Pumping Rates

The borehole capacity to sustain a given pumping rate was determined by scenario modelling using the calibrated model, where a maximum pumping

rate is limited by the aquifer capacity and/or the borehole becoming dry (ie the dynamic water level (1) falling below the bottom of the borehole). The concept of 'available drawdown' was applied per individual borehole to determine a maximum pumping rate to avoid saline intrusion. A safety buffer was applied to keep the dynamic water levels in the different boreholes above 3mamsl at all times, which is deemed sufficient to avoid saline intrusion.

A steady-state scenario was run for each of the six groundwater exploration boreholes to determine the recommended maximum pumping rates. *Table 12.20* presents the recommended maximum pumping rates, which vary from 2 to 14m^3/hour (1 to 4L/s) on a 24-hour pumping schedule per day, based on aquifer- and borehole capacity.

Table 12.20 Recommended Maximum Pumping Rates (24-Hour Pumping Rates)

Borehole ID	Casing Outer Diameter (inch)	Available Drawdown (m)	Modelled Drawdown (m)	Permissible Pumping Rates Upconing (m^3/hour)	Recommended Maximum Pumping Rates (m^3/hour)
LNG-W001	4½	2.1	2.0	20	5
LNG-W002	5	3.5	3.3	70	4
LNG-W003	4½	10.4	10.2	3,460	14
LNG-W004	5	9.4	9.1	10	5
LNG-W005	4½	8.5	8.1	30	2
LNG-W006	6½	8.7	8.5	310	7

Each of the recommended pumping rates is lower than the corresponding permissible pumping rate with regards to upconing (2) of saline groundwater.

Aquifer Capacity – Total Project Water Demand

Different pumping scenarios were evaluated to meet the borehole water demand of the Project (peak demand of 600m^3/d). Results show that the entire projected domestic water demand (including that proposed to be supplied by the desalination plant, ie a total peak demand of 1 500 - 3 000m^3/d) can be provided by borehole water, based on the overall aquifer capacity in the Project area. In order to deliver this peak demand sustainably, each of the existing boreholes (LNG-W001 to LNG-W006) would have to be pumped at their maximum pumping rate, as well as pump water from additional boreholes. The existing boreholes can deliver up to 880m^3/d sustainably. The remaining 620 – 2,120m^3/d would have to be delivered by an additional 3 – 11 boreholes assuming average pumping rates of 5 – 9.2m^3/hour (1.4 – 2.6L/s). The location of these additional boreholes required are in close proximity to LNG-W003 to LNG-W006 (as illustrated in *Annex C*).

(1) Dynamic water level describes the groundwater level in the borehole during pumping.
(2) In areas, where saline groundwater is present below fresh water aquifer, the interface between fresh and saline groundwater may rise when piezometric heads are lowered due to groundwater abstraction. This phenomenon is called interface upconing. As a result of groundwater abstraction and the subsequent lowering of the piezometric heads in the fresh and saline groundwater zone, the interface will rise. In case of over-abstraction of fresh water, the interface can rise until it reaches the pumping well. From that moment on, the quality of the abstracted water deteriorates.

Drawdown Extent

The extent of the modelled drawdowns in excess of 1m remains very localised around the pumping boreholes for all scenarios (see *Annex C* for details of each scenario). Even for the theoretical maximum impact scenarios, the calculated maximum extent of the drawdown cone (> 1m) is less than 250m from LNG-W006 and LNG-W003 respectively. The closest private water users (community boreholes HC4 and HC5) are located just under 1km away from LNG-W001 and will therefore not be impacted by any of the planned and modelled extraction of groundwater.

Surface Sealing and Infilling- Effects on Groundwater Levels and Recharge

The sealing of a surface with concrete results in increased stormwater run-off, reduced direct groundwater recharge and has the potential to lower the water table which could result in seawater intrusion. As FEED has not yet been completed, the final footprint of the LNG Processing Area and the areas to be sealed within have not yet defined. This study has therefore, assessed the sealing of two different surface areas, as followings:

1. LNG Processing Area (6km^2); and
2. LNG Processing Area and adjacent associated infrastructure (14km^2).

The location of these areas is shown in *Annex G*. The surface sealing scenarios were run in steady-state to quantify long-term impacts on the groundwater system. Modelling results show that reduced groundwater recharge due to surface sealing results in groundwater level drawdowns in the order of tens of centimetres which is considered insignificant (see *Annex G*).

Combined with in-filling of Catchment B, the groundwater levels for both scenarios modelled rise due to the decrease in groundwater discharge. Modelling results suggest that groundwater levels will rise between 1 and 1.3m for the LNG Processing Area (6km^2) and the LNG Processing Area and adjacent associated infrastructure (14km^2) respectively. Groundwater levels will exceed ground surface, based on the corrected topography, by up to 1m and this is likely to result in flooding of the filled-in estuary and surroundings if the ground surface is not raised during construction.

Sealing of the LNG Processing Area results in a reduction of groundwater recharge of 2,050m^3/d (- 4%), whereas sealing of the LNG Processing Area and adjacent associated infrastructure results in a reduction of 4 510m^3/d (- 8.8%). However, the infilling of the estuary in Catchment B combined with surface sealing results in an increased groundwater discharge into Palma Bay of 170 – 810m^3/d (+ 0.8% to + 3.6%). As the volumes are small this will have an insignificant impact.

Conclusion

Scenario modelling has shown that the planned groundwater abstraction will result in minimal drawdown localised around the production boreholes (*viz.* within 250m radius of the pumped borehole). As the closest community well and boreholes are located at distances > 800m from the production boreholes, none are within the modelled cone of depression. Further, if the recommended pumping rates are adhered to, seawater intrusion can be avoided. The planned groundwater abstraction will result in insignificant reduction of fresh water baseflow to the surface water ecology including estuaries, mangrove stands, wetlands and streams.

The planned surface sealing (ie using concrete) within the proposed LNG Processing Area will increase stormwater run-off, reduce direct groundwater recharge and potentially lower the water table which could result in seawater intrusion. Conversely, the proposed in-filling of Catchment B would impact the extent of the groundwater discharge area, resulting in groundwater level rise and associated flooding. Modelling results suggest that the groundwater level rise due to infilling of Catchment B will be more significant and therefore, the combined impact will result in groundwater level rise between 1 and 1.3m, resulting in the water table exceeding the current ground surface by up to 1m within the LNG Processing Area. During FEED this will be taken into consideration to prevent flooding of this area, through raising the topography and/or installing sub-surface drainage. This potential impact to the Project is therefore not considered further.

12.8.3 Impact of Groundwater Abstraction on Community Groundwater Users

Impact Assessment

Groundwater abstraction from the production water supply wells may result in the lowering of groundwater levels (drawdown) in and around abstraction boreholes. This has the potential to result in changes to the natural groundwater flow regime in the areas adjacent to the production water supply wells. Considering that the Project requires between 80 – 600m^3/d of groundwater during the construction and operational phases, the potential exists for shallow community supply wells and boreholes located within the zone of influence of a production borehole to be negatively impacted though the lowering of groundwater levels. Peak groundwater volumes will be required in Year 2 of the Project (600m^3/d), ie during construction, after which a desalination plant will be installed. Minimal groundwater volumes will be required thereafter (between 60 - 150m^3/d) during the operational phase.

However, modelling has shown that the planned groundwater abstraction will result in minimal drawdown localised around the production boreholes (*viz.* within 250m radius of the pumped borehole). As the nearest community groundwater wells and boreholes are located at distances > 800m from the production boreholes, none are within the modelled cone of depression (within 250m radius of the pumped borehole). In addition, considering the

high transmissivities exhibited by the aquifer, potential impacts on the community wells is considered unlikely.

Over-abstraction of production wells could lead to seawater intrusion and salinization of the fresh-water aquifer, resulting in a site-specific long-term impact. This impact is unlikely should recommended pumping rates be adhered to. Combined with potential low magnitude, the potential impact is of NEGLIGIBLE significance. The degree of confidence in the assessment is medium and is based on modelled results.

Mitigation Measures

After FEED, should the Project water demand and/ or proposed maximum abstraction rate increase, the model should be re-run to verify that groundwater use will not result in the lowering of groundwater levels at shallow community supply wells and boreholes.

Once groundwater abstraction begins, dynamic groundwater level of ≥ 3 m amsl must be maintained within the production boreholes. To achieve this, submersible pumps should be equipped with automated switches that turn off should the water level in the production borehole fall below 3 m amsl. At the end of Year 2 of the Project, the groundwater model should be validated using actual monitoring data from the construction phase of the Project and if necessary re-calibrated.

Residual Impact

The residual impact of increased groundwater abstraction on community wells and boreholes is anticipated to remain NEGLIGIBLE for the Project base case.

Table 12.17 Impact of Groundwater Abstraction on Community Groundwater Users

	Without Mitigation	**Residual Impact (With Mitigation)**
	Construction and Operational Phases	
Duration	Long-term	Long-term
Extent	On-site	On-site
Intensity	Low	Low
Magnitude	**Low**	**Low**
Likelihood	**Unlikely**	**Unlikely**
Significance	**NEGLIGIBLE**	**NEGLIGIBLE**

12.8.4 Impact of Groundwater Abstraction on Surface Water Ecology

Impact Assessment

Groundwater abstraction from production boreholes (peak abstraction of 600m^3/d) will result in the lowering of groundwater levels (drawdown) in the immediate vicinity of the pumped borehole and will alter the natural groundwater flow regime in the area.

Under natural conditions, aquifers contribute baseflow to estuaries, wetlands and mangroves in the Afungi Project Site. The baseflow contribution from groundwater could be reduced should groundwater abstraction result in the lowering of the water table. Further, the hydrochemistry of the fresh-water ecosystem could be altered due to seawater intrusion.

The potential impact of groundwater abstraction on the surface water ecology is expected to be confined on-site. In addition the modelling shows that for the expected peak rate of abstraction, salt water intrusion is unlikely. Based on the recommended pumping rates and schedules, the reduction of groundwater discharge to estuaries will be of maximum 0.6% (-50m^3/d) and to wetlands and streams of maximum 0.03% (-10m^3/d). This reduction in groundwater flow is considered insignificant. Therefore a low magnitude impact is expected. Combined with the unlikely probability of occurrence, the potential impact is expected to be NEGLIGIBLE. The degree of confidence in the assessment is medium and is based on modelled results.

Mitigation Measures

To avoid adverse impacts on surface water ecology associated with groundwater abstraction, it is recommended that the same suite of mitigation measures outlined in *Section 12.8.2* be implemented.

Residual Impact

The residual impact of increased groundwater abstraction on surface water ecology is anticipated to remain as NEGLIGIBLE.

Table 12.18 Impact of Groundwater Abstraction on Surface Water Ecology

	Without Mitigation	**Residual Impact (With Mitigation)**
	Construction and Operational Phases	
Duration	Long-term	Long-term
Extent	On-site	On-site
Intensity	Low	Low
Magnitude	**Low**	**Low**
Likelihood	**Unlikely**	**Unlikely**
Significance	**NEGLIGIBLE**	**NEGLIGIBLE**

12.9 SURFACE WATER ECOLOGY

12.9.1 Overview

This section provides a description of the potential impacts the proposed Project may have on wetland and aquatic ecology. The key receptors or resources considered are both the lacustrine (fresh water) and estuarine wetlands found within or adjacent to the Afungi Project Site and the ecological functions these wetlands provide. Specific focus has been given to the aquatic species, flora and fauna dependent on these systems. Project activities likely

to result in adverse impacts to the wetland systems are predominately related to the construction phase, and are largely permanent in nature. However, additional impacts are likely to occur during the operational phase.

12.9.2 Impact of Site Clearance and the Reclamation of Wetlands (Lacustrine and Estuarine) on Wetland Habitat and Ecological Functions Provided by These Wetlands

Impact Assessment

Site clearance and preparation activities will potentially result in the permanent loss of both lacustrine and estuarine wetlands of Catchments A, B and E and small areas of the aquatic wetlands of Catchment C (as shown in *Figure 12.33*, and the ecological functions provided by these wetlands. These wetlands that fall within the Project Footprint Area will be reclaimed by infilling the wetlands with marine sediment dredged from Palma Bay.

Catchments B, C and E have a high wetland significance (see *Section 8.6*), based on the presence of IUCN Red Data species of flora and fauna within both the estuaries and fresh-water wetlands. The estuaries within Catchments A, B, C and E play an important role as nursery areas for marine fish species, as well as numerous resident biota that rely on the estuaries and the associated habitat provided by the mangroves. Although diverse in terms of mangrove species, the stands that will be infilled are not unique in Palma Bay or the larger region (Richmond, 2002). In addition, local subsistence agriculture occurring within the Afungi Project Site is focused around wetlands and has displaced a great deal of the natural riparian vegetation, and remaining riparian vegetation is not considered to be in a pristine state.

40°30'0"E 40°32'30"E 40°35'0"E

10°47'30"S 10°50'0"S 10°52'30"S

Palma
Palma Bay
MOZ6
MOZ11
MOZ4
MOZ5
Quitupo
MOZ3
MOZ10
MOZ12
MOZ2
MOZ7
MOZ1
MOZ9
Senga
Maganja
MOZ8
A
B
C
D
E

bing

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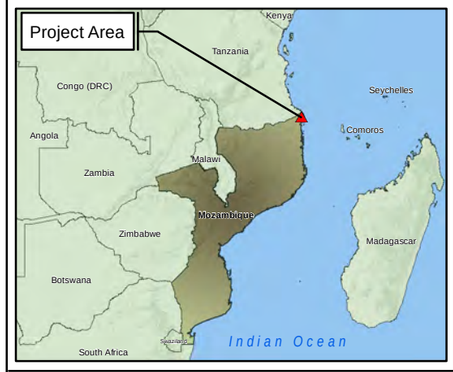
Legend

- Villages / Settlements
- Contours
- Local Roads
- Nearshore Components
- Onshore Project Footprint
- Afungi Project Site
- Aquatic and Wetland Sites
- Wetland Groups

Wetlands

- Estuary
- Permanent wetland
- Seasonal wetland
- Un-Delineated wetlands
- Wetland Buffer (150 m)



MAIN MAP SCALE:

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Metres

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TITLE:

Figure 12.33:
Wetland Catchments and Onshore Project Footprint Area

CLIENT:

Anadarko Moçambique Área 1, Lda
eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 50 000

DRAWING: Wetlands Catchments OPF.mxd
REV: A

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Impacto Projectos e Estudos Ambientais
ERM

Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
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Inset Map: Esri Data & Maps

SIZE: A3

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The killifish that were observed in Catchments B and C have only been recorded prior to this study in 2007, in Nassoro Village, located approximately 20km southwest of the Afungi Project Site (Valdesalici, 2007). Thus the species is assumed to have a highly restricted geographical range. The reclamation of the aquatic wetlands of Catchment B and a small area of Catchment C will result in a loss of two of the three known habitats of this species – although given that it was observed in two of the five catchments sampled, it is possible that the species may occur in other wetlands in the area.

A review of publically available satellite imagery of the wider area, including northern Mozambique and southern Tanzania, was undertaken. The imagery revealed approximately 20 estuaries in the coastal zone within 100km of the Afungi Project Site, with varying catchment sizes feeding them. These estuaries include the large Rovuma Estuary as well as the Palma Estuary, which have extensive mangrove communities. The satellite imagery also revealed what appear to be a number of superficially similar wetlands along the coastline. These are restricted to areas north of Palma and north and south of Mocímboa de Praia. Lacustrine wetlands, including broad permanent swamps, with characteristics similar to those found in the Afungi Project Site, appear to be common to the northern Mozambican coastline. However, their actual similarity in terms of wetland characteristic and habitat types to the wetlands of the Afungi Project Site is not certain, as they have not been surveyed. Such wetlands do not appear to occur along the southern Tanzanian coast. It is not known whether the Lindner's toad, snoring leaf-folding frog and killifish, which are documented to be restricted in extent, are found in other wetlands along the northern Mozambican coast, but it is possible.

The loss of wetland and estuarine habitat is an onsite impact that will result in the loss of ecological functions provided by the wetlands, and specifically the loss of habitat for a number of species of conservational concern or importance. The impact will result from site preparation activities associated with the construction phase, and will be permanent in duration. The intensity of the impact depends on the overall ecological function of the habitat type and its respective species composition, and on the availability of similar habitat types outside the impacted area. It is reasonable that that similar habitats and ecological functions occur outside the disturbance area, but this has not been confirmed by direct assessment. As a precautionary measure, the intensity is estimated to range from Medium to High. A High magnitude impact is expected due to the presence of Red Data species of flora and fauna. The likelihood of the impact occurring is definite, and results in a MAJOR significance impact. The degree of confidence in the assessment is Medium.

Mitigation Measures

The primary mitigation measure to reduce the impact is to revise the Project Footprint Area so as to minimise footprint impacts on wetlands. *Figure 12.34* illustrates the Revised Project Footprint. The Project will develop a Wetland Management Plan which will include following mitigation measures:

- The extent to which the Project Footprint Area encroaches onto the lacustrine wetlands and the 150m buffer zone around these wetlands will be minimised to avoid the loss of the wetland systems. In particular:

    - the Project Footprint Area will be minimised to avoid reclamation and loss of the wetland and estuary of Catchment A;

    - the Project Footprint Area will be minimised to avoid reclamation and loss of the wetlands of Catchment C; and

    - the Project Footprint Area will avoid reclamation and loss of the wetland and estuary of Catchment E.

- A diversion channel will be designed and implemented to divert flow from the lower reaches of Catchment B eastwards towards the estuary of Catchment E, as illustrated in *Figure 12.34*.

- Catchments C and D are outside the Project Footprint Area, but need to be monitored going forward to confirm that indirect or secondary effects are minimised. Catchment A will be monitored as it is most likely to be affected by adjacent Project activities. In this regard, parameters will be monitored once a month for at least six months before construction starts to establish baseline conditions. The following parameters will be monitored at three points within each wetland A, C and D, at the bottom (estuary), middle and top of the wetlands:

    - TSS;
    - hydrocarbons (oil and diesel);
    - pH;
    - salinity (must include magnesium, potassium, sodium, calcium);
    - conductivity;
    - dissolved oxygen;
    - nitrites, nitrates and ammonia; and
    - sulphates.

- During construction and operations, monitor the same parameters once every six months. Should the parameters increase or decrease by more than 10 to 15 percent, the Project will investigate the cause and remedy the situation. If required, appoint a specialist to assist.

- Install water level gauges in Catchments A, C and D and monitor water levels once a month for at least 12 months before construction starts, to establish a baseline. Monitor water levels once every six months for the wetlands in Catchment C and D, and once a month for the wetland in Catchments A and E, during construction and operations. If water levels increase or decrease by more than 10 to 15 percent from the established baseline, the Project will investigate the cause and remedy the situation.

- Once a month during construction and operations, undertake a visual inspection to check whether estuary mouths are becoming filled with sediment and closing. This could be an indicator of low flows coupled with high sediment load.

- Twice annually (once during high flow and once during low flow), undertake a detailed aquatics assessment in the wetlands in Catchments A, C and D. Monitor for macro-invertebrates, fish and microalgae. Monitor for changes in trends, and appoint a specialist if necessary to interpret and rectify any adverse changes in the PES category. Continue this monitoring until steady-state conditions are observed with respect to the presence/absence of the species monitored.

- To offset impacts on directly impacted wetlands and estuaries, other wetlands areas in the Afungi Project Site should be rehabilitated by removing crops and allowing the natural regrowth of indigenous species. This will have the positive effect of reducing current agricultural impacts on the riparian vegetation and surface water quality, and will promote natural restoration of these habitats and provide improved habitat for a wide diversity of floral and faunal species.

- Disturbed areas will be revegetated with a diversity of naturally occurring tree species, including locally endemic species such as *Berlinia orientalis*.

- The outer limits of wetland buffers in the vicinity of planned developments will be surveyed, clearly defined on the ground and marked as no-go areas prior to the onset of construction activities.

- Comprehensive planning of construction should be conducted prior to the onset of activities. Storage and laydown areas, vehicle parking areas and workers' facilities such as accommodation, eating halls and toilet facilities need to be clearly specified, and activities should be restricted to these areas. Construction staff and contractors should be informed of the importance of minimising their footprint and restricting activities to these areas.

- The deposition of dredge material onshore will be restricted to the areas to be infilled.

- The Project will develop a site management strategy. This strategy will include the following measures to reduce impacts to estuaries:

    - dredge material storage areas will be designed to prevent salt-water run-off spilling out and affecting adjacent salt-intolerant vegetation;

    - erosion and sediment control measures and practices will be implemented; and

- reclaimed estuaries will be filled in from the upper reaches towards the bay to allow motile organisms, fish and crabs to escape to the downstream Palma Bay water body and shoreline.

40°30'0"E 40°32'30"E 40°35'0"E

10°47'30"S 10°50'0"S 10°52'30"S

Legend

- Villages / Settlements
- Local Roads
- Nearshore Components
- Revised Project Footprint
- Afungi Project Site
- Proposed Diversion Channel

Wetlands

- Estuary
- Permanent wetland
- Seasonal wetland
- Un-Delineated wetlands
- Wetland Buffer (150 m)

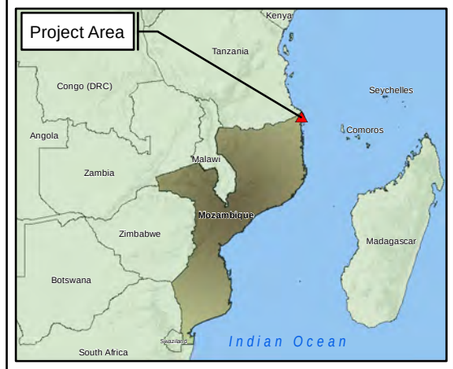

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Figure 12.34: Revised Project Layout including proposed Location for Wetland Diversion

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 50 000

DRAWING: Wetlands Revised OPF.mxd

REV: A

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ERM

Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
Natural Scientific Services CC, 2012.

SIZE: A3

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Residual Impact

The reconfiguration of infrastructure in the Revised Project Footprint Area (*Figure 12.34*) reduces the loss of wetland, aquatic and estuarine habitats within Catchments A, C and E by 402ha, and the loss of wetland buffer by 174ha. The intensity is thus reduced to Medium. In addition, the restricted public access, the protection of greenbelts and the rehabilitation of existing agricultural sites within wetlands and their buffers will partially offset the loss of wetland habitat within the Revised Project Footprint Area. The magnitude is considered to be Medium and, coupled with the definite likelihood, the residual impact is reduced to MODERATE significance.

Table 12.21 Impact of Site Clearance and the Reclamation of Wetlands (Lacustrine and Estuarine) on Wetland Habitat and Ecological Functions Provided by These Wetlands

	Without Mitigation	**Residual Impact (with Mitigation)**
Construction Phase		
Duration	Permanent	Permanent
Extent	Onsite	Onsite
Intensity	Medium to High	Medium
Magnitude	**High**	**Medium**
Likelihood	**Definite**	**Definite**
Significance	**MAJOR**	**MODERATE**

12.9.3 Impact of a Change in Water Quantity and Flow Regime on Wetland Habitat (Lacustrine and Estuarine), Functionality and Aquatic Ecology

Impact Assessment

Hydrology is one of the three drivers in wetland formation. The current slow flow in the wetlands within the Afungi Project Site is a determinant of the physical habitat in these wetlands, which in return determines the biotic composition. Assuming that Catchments A, B and E will be reclaimed based upon the proposed Project Footprint Area, this impact is only assessed for Catchments C and D. A change in the quantity of water within the wetlands and in the flow regime of the wetlands could fragment the systems, disrupt seasonality and functionality, alter the aquatic and riparian habitat and influence species diversity, composition, distributions and abundances. Most of the wetlands within the Afungi Project Site have small localised catchments, and hydrology of these systems could be affected by the following construction and operational activities:

- removal of natural vegetation;
- hardening of surfaces;
- construction and operation of roads;
- stormwater run-off; and
- use of groundwater and potential lowering of the groundwater table.

Clearing of vegetation and hardening of surfaces during the construction phase will result in less rainwater being able to infiltrate the soil. This has the potential to reduce the natural recharge of the wetlands of Catchments C and D. The LNG Process Areas will be bunded to capture potentially contaminated stormwater run-off. Stormwater run-off from this area will be directed to treatment areas prior to storage in the stormwater retention basin. Following treatment (to applicable standards), this water will be mixed with other treated effluents and discharged into Palma Bay.

The net result of this treatment, storage and discharge may reduce the natural water flows to wetlands and result in a change in flooding frequencies. However, in natural wetland habitats, the majority of species present usually have preferences for slow-deep or slow-shallow conditions with a high percentage of vegetation for cover. Thus, a decrease in flow rate is expected to have limited effects.

Estuaries need seasonal fluctuations to maintain natural salinity levels within the ecosystem. The Project could potentially result in decreased flows into the wetlands as a result of run-off being treated and discharged into Palma Bay. A decrease in water quantity within the fresh-water wetlands can lead to changes in channel shape and patterns of sedimentation, present barriers to fish migration and changes of biological communities. In terms of the macro-invertebrates present, most of the families are not expected to be significantly impacted, as the majority of the macro-invertebrates present are generally tolerant to fluctuations in water volumes, depths and water quality (Thirion, 2008; Ngupala & Kayanda, 2010). Having said this, there are some instances where macro-invertebrates have been shown to be indirectly influenced by abstraction, such as through loss of preferred habitat, water chemistry changes and increases in periphyton biomass (Brooks et al., 2010). According to Ngupala and Kayanda (2010) certain fish species like sharptooth catfish (*Clarias gariepinus*) and Mozambique tilapia (*Oreochromis mossambicus*) thrive in slow/standing deep habitats (Skelton, 2001). Hence these species may be favoured by a decrease in flow.

Little is currently known about the effects of decreased fresh-water inflow on the biota of estuarine environment. However, according to Allanson and Baird (1999), decreased flow may lead to:

- a change in the substrate, often in the form of increased particle size (sand);
- closure of the mouth of the estuary;
- development of hypersaline conditions;
- reduction in nutrients, making the system dependent upon tidal exchange to supply these nutrients;

- decrease in depth and water area; and

- reduction in productivity at all trophic levels, and possibly a loss in biodiversity.

In addition, it is known that a reduction in fresh-water inflow can lead to reduced scouring and altered salinity. The reduced scouring effect of the fresh water may potentially reduce the frequency of the estuary mouth being open to the sea, which will lead to a loss in nursery function and biodiversity (Allanson & Baird, 1999; Cyrus & Wepener, 1997).

The impact of a change in hydrology (flow and water quantity) in the systems of Catchment C (and potentially Catchment D) will be local, as the catchments extend beyond the limits of the Afungi Project Site. The impact will be permanent and of Medium intensity once the Project Footprint Area has been cleared of vegetation, and once the topsoil had been removed and the area surfaced. The magnitude is predicted to be Medium once the Project Footprint Area has been cleared of vegetation, and once the topsoil has been removed and the area surfaced. The impact will be definite, and therefore the impact significance of reduced water quantity and a change of flow will be MODERATE within these catchments during the construction and operational phases.

Mitigation Measures

Project will develop a Wetland Management Plan which will include the following mitigation measures:

- Wherever possible, avoid impermeable hard surfacing in favour of semi-permeable surfaces.

- Stormwater management should encourage infiltration of clean stormwater into the soil.

- Work within designated work areas and limit vegetation clearance to the minimum necessary.

- Following site clearance, vegetation needs to be encouraged and managed as part of a revegetation programme.

- Install water level gauges in Catchments A, C and D and monitor water levels once a month for at least 12 months before construction starts to establish a baseline. Monitor water levels once every six months for the wetlands in Catchments C and D, and once a month for the wetland in Catchment A during construction and operations. If water levels change significantly from the established baseline, the Project will investigate the cause and remedy the situation.

- Twice annually, once during high flow and once during low flow, undertake a detailed aquatics assessment in the wetlands in Catchments A, C and D. Monitor for macro-invertebrates, fish and microalgae. Monitor for changes in trends and appoint a specialist if necessary to interpret and rectify any deterioration. Continue this monitoring until steady-state conditions are observed with respect to the presence/absence of the species monitored.

- No water will be pumped from wetlands (for Project need).

- No effluent will be discharged into the fresh-water or estuarine wetlands.

- No impoundments or ponds will be constructed within any of the wetlands or within the 150m buffer zone around streams and wetlands.

- Wherever possible, upgrade existing roads rather than building new ones.

- If structures (eg overpasses) are required to cross streams, construction will, wherever possible, minimise in-stream supporting structures to ensure minimal impact on the in-stream habitat.

- Hardened surfaces will be broken up upon closure of the Project and the areas will be returned to a free-draining state, in accordance with the Decommissioning and Rehabilitation Plan (see *Annex F*).

Residual Impact

With the implementation of the above mitigation, impact intensity and magnitude will be reduced in Catchments C and D during both the construction and operational phases, and impact significance will be MINOR. Similarly, if flow rates and water quantity entering Catchment E as a result of the installed diversion from Catchment B are controlled properly, impact significance will also be MINOR.

Table 12.22 Impact of a Change in Water Quantity and Flow Regime on Wetland Habitat (Lacustrine and Estuarine), Functionality and Aquatic Ecology

	Without Mitigation	**Residual Impact (with Mitigation)**
	Construction Phase	
Duration	Permanent	Permanent
Extent	Local	Local
Intensity	Medium	Low
Magnitude	**Medium**	**Low**
Likelihood	**Definite**	**Definite**
Significance	**MODERATE**	**MINOR**
	Operational Phase	
Duration	Permanent	Permanent
Extent	Local	Local
Intensity	Medium	Medium
Magnitude	**Medium**	**Low**
Likelihood	**Definite**	**Definite**

	Without Mitigation	Residual Impact (with Mitigation)
Significance	**MODERATE**	**MINOR**

12.9.4 Impact of a Change in Water Quality within the Wetlands (Lacustrine and Estuarine) on Aquatic Ecology

Impact Assessment

A change in water quality variables, either physical (turbidity, suspended solids, temperature, oxygen) or chemical (nutrients, trace metals, hydrocarbons), can affect the functioning of an aquatic ecosystem. Each variable has an effect, either beneficial or detrimental, on aquatic organisms. The overall effect when more than one variable is involved is dependent on whether they act synergistically or antagonistically. The effect of each variable is also influenced by the tolerance limit of an organism, the duration of exposure and the concentrations of contaminants. In addition to individual variables, aquatic ecosystems are often the ultimate receivers of effluents from a combination of water quality variables from many sources. The impact of increased turbidity or a change in sedimentation patterns are assessed separately in *Section 12.9.5*.

Changes in water quality may gradually change the constituent species of a biotic community until it is no longer recognisable as the same community (Dallas & Day, 2004). Changes to water quality could result in:

- relocation of a community of aquatic organisms;
- the introduction or loss of species;
- reduction in diversity as a result of increases in the concentration of toxins such as trace metals; and
- reduced ecosystem functioning.

As described in *Chapter 4*, sewage, process effluents from the LNG Facility and stormwater run-off will be treated and discharged into Palma Bay, and the fresh-water wetlands and estuaries will not be affected from these sources within the Project Footprint Area. However, outside of the LNG Process Area, stormwater run-off from roads or unsurfaced areas could result in undesirable water quality constituents entering the wetlands and, subsequently, the estuaries within the Afungi Project Site. For example, fertilisers may be used within the landscaped areas of the site and could lead to increased nutrients within the wetlands. Surface water run-off or leachate from the proposed landfill site could be another source of pollutants.

Dredging in Palma Bay will be undertaken to accommodate access by the pipeline lay barge, as well as LNG Carriers. The dredge material is planned to be used to fill in the estuary in Catchment B and for construction of the MPD.

Sediment analysis shows that all parameters were within acceptable levels in the proposed dredge areas (Lwandle, 2012). Thus, the potential for impact from dredge material affecting water quality is negligible. Salt water from the dredge material will be directed back into the bay and, hence, will not affect the water quality of fresh-water wetlands.

Minor spills and leaks that tend to occur during normal activities could affect wetland water quality and the biotic environment within these sensitive ecosystems. These impacts typically arise from poor maintenance of machinery, resulting in petroleum fuel, oil or hydraulic leaks. These substances and their constituents, in particular hydrocarbons and heavy metals, are potentially toxic to aquatic ecosystems. These can have acute as well as chronic effects on flora and fauna within the systems, resulting in the potential loss of sensitive biota. Furthermore, a loss of biodiversity resulting from spills/leaks could lead to changes in the community structure, such as the loss of sensitive species and the dominance of tolerant organisms. Impacts associated with larger spills resulting from leaks or rupture of storage tanks are assessed in *Chapter 14*.

The potential effects to fish and macro-invertebrate species are a function of the type of pollutant, concentration and the duration of exposure. Following a spill, both diesel and fuel oil will float to the surface of the water, and a small fraction will mix into the water column. Impacts associated with a small spill will have no significant impact on aquatic species, as the fuel/oil will quickly disperse and will not cause a detectable effect. However, impacts may result from a larger spill.

A change in flow rate or sedimentation patterns in a system can also impact the physical and chemical variables such as temperature, oxygen, turbidity, salinity levels, etc. Project discharges into Palma Bay may also affect the salinity profile in estuaries, thereby impacting on the various aquatic biota utilising the estuary. Effects may be most evident among anadromous and other fishes (eg early life-history stages) that are particularly sensitive to salinity, especially during transitions from fresh water to saline water (Nightingale & Siminstad, 2001). Mangrove growth and development, particularly of seedlings, are also affected by sediment salinity. Growth is negatively influenced by both low salinity (<12 PSU) as well as hypersalinity (60 PSU) (Sobrado, 1999; Tuffers et al., 2001). It is estimated that benthic environments can tolerate an increase in salinity of 1 PSU to 2 PSU above the ambient salinity of sea water. The ambient salinity in Palma Bay is approximately 35 PSU. PRDW (2012) has modelled the brine discharge, and increases in salinity at the estuaries in Catchments A and E range from 0.0048 PSU to 0.02400 PSU in the wet season, and from 0.0120 PSU to 0.0240 PSU in the dry season. These are negligible changes to ambient salinity levels.

From the above, it is clear that the activity most likely to affect water quality is run-off from roads and other areas that fall outside the LNG Process Area, as well as the risk of spills within the near shore. These impacts would be felt

during the construction and operational phases of the Project. Based on the Natural (1) to Largely Natural (2) state of the wetland systems within Afungi Peninsula (see *Section 8.6*), the current water quality and the severity of the effects of a potential change in the levels of physical or chemical constituents in the systems, impact intensity is considered to be Medium in the construction phase and Low to Medium in the operational phase, once stormwater management systems are in place. Impact magnitude is likely to be Medium during the construction phase and Low to Medium in the operational phase. The probability of occurrence is expected to be Likely. Without mitigation, the significance of the impact is assessed as MODERATE during construction and MINOR to MODERATE during the operational phase. The degree of confidence in the assessment is High.

Mitigation Measures

Project will develop a Wetland Management Plan which will include the following mitigation measures:

- Modify layout such that wetlands in Catchments A, C, D and E are not lost or disturbed. This limits the extent of water quality impacts.

- Locate roads away from wetland areas to limit the erosion and sediment infiltration to wetlands.

- Implement erosion and sediment control measures and practices.

- Intercepting channels will be provided to prevent stormwater run-off from washing across exposed soil surfaces.

- Buffer zones on the estuaries will be strictly adhered to, as they can potentially reduce the impact of run-off as they capture sedimentation as well as potential constituents. Stockpiles and waste dumps will not be located within 150m of streams or wetlands. Stockpiles will be covered if erosion is a problem.

- No effluents will be discharged into the wetlands.

- Any storage facilities containing hazardous substances will be lined, bunded or otherwise designed to prevent seepage and impact to surface or groundwaters.

- Vehicles, vessels and equipment working onshore near the estuaries or in the near shore will be serviced regularly.

(1) Unmodified state with no impacts, conditions natural.
(2) Largely natural with few modifications. A small change in natural habitats and biota may have taken place, but the ecosystem functions are essentially unchanged.

An Emergency Response and/or spill contingency plan will be in place for any accidental spillage. Spill containment and clean-up kits will be available onsite, and clean-up from any spill must be in place and executed at the time of a spillage, with appropriate disposal as necessary.

Monitoring measures are as follows.

- All monitoring of the wetlands within Catchments A, C, D and E will commence before the start of construction to quantify the normal monthly and seasonal variations of these wetlands.

Once baseline conditions have been established, the following monitoring will be implemented.

- Water quality of the wetlands within Catchments A, C, D and E after construction will be monitored on a monthly basis. Monitoring sites will be located upstream and downstream of any potential points of impact. The constituents that will be monitored include:

    - pH, dissolved oxygen, conductivity, suspended solids, salinity, nutrients, metals and hydrocarbons (particularly those associated with Project operations);

    - algal presence and eutrophication; and

    - frog species diversity and number of sensitive species (frogs are a good indicator of water quality in wetland environments) – should diversity or numbers start to decline, the cause will be investigated and the situation remedied.

- If significant variations from baseline conditions are observed, the cause will be investigated and rectified.

- A Wetland Management Plan will be developed, which will specify requirements to monitor flow rates through the wetlands within Catchments A, C, D and E.

Residual Impact

The above mitigation measures are expected to reduce the intensity and magnitude of the impact. The impact significance is thus reduced to MINOR for both the construction and operational phases.

Table 12.23 Impact of a Change in Water Quality within the Wetlands (Lacustrine and Estuarine) on Aquatic Ecology

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Short term	Short term
Extent	Local	Local
Intensity	Medium	Low
Magnitude	**Medium**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MODERATE**	**MINOR**
Operational Phase		
Duration	Long term	Long term
Extent	Local	Local
Intensity	Low to Medium	Low
Magnitude	**Low to Medium**	**Low**
Likelihood	**Definite**	**Likely**
Significance	**MINOR to MODERATE**	**MINOR**

12.9.5 Impact of Increased Turbidity and Change in Sedimentation Patterns on Biological Features of Wetlands (Lacustrine and Estuarine)

Impact Assessment

Activities such as the removal of vegetation, site levelling, grading, infilling of the wetlands and estuaries, trench excavation and backfilling, rehabilitation and the use of existing dirt roads are likely to cause erosion and generate dust, and result in a relatively rapid increase in sediment load in the wetlands if not controlled. In addition, dredging in Palma Bay (both capital and maintenance) is likely to result in increased suspended solids entering the estuaries.

Assuming that Catchments A, B and E will be reclaimed based upon the proposed Project Footprint Area, this impact is assessed in terms of Catchments C and D. The estuaries associated with these catchments may be affected by increased sedimentation from either the marine environment or the upstream fresh-water wetlands. High levels of suspended solids were observed in each of the catchments sampled. The aquatic functioning of these systems seems to be adapted to high levels of suspended solids. However, a substantial increase in sedimentation patterns within Catchments C and D may affect the following:

- Connectivity of the wetlands: increased sedimentation can lead to barriers, causing the loss of connectivity within the fresh-water wetlands and between the fresh-water wetlands and the estuaries. The fragmentation of the systems can lead to the isolation of populations, failed migration, increased crowding, increased competition and local extinction of species.

- In-stream habitat conditions: increased sedimentation can cause changes in streambed conditions (ie the porosity and composition of the aquatic

streambeds). This increases the embeddedness (1) of the streambed and changes the streambed composition and, in extreme cases, the channel morphology (Reid & Anderson, 1999).

- Primary production of the wetlands: turbidity determines the degree of penetration of light, and hence impacts the photosynthesis of plants. Light penetration is reduced from increased turbidity, which can lead to a decrease in primary production and food availability for organisms higher in the food chain (Dallas & Day, 2004; Wood & Armitage, 1997).

- Benthic invertebrate communities: a change in the suitability of the substrate composition can affect some benthic taxa, and increased drift (ie the rate at which organisms move by floating downstream) affects respiration and feeding activities. Temperature-sensitive species may also be affected, as increased turbidity in the water column can reduce temperature as less heat is absorbed by the water and more heat reflected by the surface (Dallas & Day, 2004; Wood & Armitage, 1997).

- Fish species: high turbidity and suspended sediment concentrations cause physiological effects in fish (ie impairment of gill function or reduced resistance to diseases), a reduction in suitable spawning habitat and hindering of development (eggs, larvae and juveniles), and changes in migration patterns. Other potential effects include a reduction in food availability, due to a decrease in primary production and habitat loss, and intervention with hunting efficiency (Dallas & Day, 2004; Wood & Armitage, 1997). In estuaries, a number of marine fish species rely on mangrove systems as a nursery ground for juvenile fish eg *Chanos chanos*. Suspended sediment and the duration of exposure can impact juvenile fishes, which usually thrive in rivers and estuaries with naturally high concentrations of suspended sediments (Nightingale & Siminstad, 2001).

The extent of the impact is local, as Catchments C and D extend beyond the Afungi Project Site and may potentially be affected by a change in sedimentation patterns. The impact will arise during all phases of the Project. The impact duration will be short term within the fresh-water wetlands, but long term in the estuaries. The intensity of the impact is dependent on the volume of sediments entering the aquatic system, wetland size, volume of flow, bed material and sedimentation rate. It is likely to be Medium during the construction phase and Negligible during operations, should levels of turbidity or sedimentation increase beyond what the system can tolerate. Impact magnitude is Medium during the construction phase and Negligible during the operational phase.

Impacts will be Likely during construction and Unlikely during operations. The significance is therefore considered be MODERATE during the

(1) The extent to which larger particles such as rocks and stones are buried by silt, sand or mud on a streambed.

construction phase and NEGLIGIBLE during the operational phase. The degree of confidence in the assessment is High.

Mitigation Measures

Project will develop a Wetland Management Plan which will include the following measures:

- Implement erosion and sediment control measures and practices.
- Wetlands outside the Project Footprint Area will be considered as sensitive areas, and a minimum 150m buffer zone around them will be maintained.
- Intercepting channels will be provided to prevent stormwater run-off from washing across exposed soil surfaces.
- Where possible, locate roads away from wetland areas to limit the erosion and sediment loads reporting to wetlands.
- Surface water management structures within the construction areas must include stream diversion channels, internal run-off capture and diversion channels, to control sedimentation wherever necessary.
- Where required, drainage channels will be provided onsite to direct stormwater to sand/silt traps for the removal of soil particles.
- Adherence to the 150m buffer zone will be regularly monitored and enforced.
- All exposed areas will be stabilised once the covering vegetation has been removed.
- Monitor stockpiles for erosion and implement erosion control measures if required.
- Adequate dust control strategies will be applied to minimise dust deposition and reduce sedimentation in the wetland systems, for example:
    - periodic spraying of roads with water or dust inhibitor; and
    - covering transport trucks hauling materials that have the potential to become airborne, to prevent dust emission during transport.
- Silt curtains or traps or another industrial equivalents will be used to restrict the spread of suspended sediments into the wetlands and estuaries. These can be placed downslope of where vegetation stripping will take place, to minimise siltation in the estuaries. The sediment removal facilities will be cleaned and maintained on a regular basis to

ensure the optimal functionality of the facilities, to prevent sedimentation in wetlands.

- Monitor the turbidity and suspended solids on an ongoing basis as part of a surface water monitoring programme, to ensure that levels do not increase or decrease by more than 10 to 15 percent of current baseline levels.

- Once a month during construction and operations, undertake a visual inspection to check whether estuary mouths are becoming filled with sediment and closing. This could be an indicator of low flows coupled with high sediment load.

Residual Impact

The reconfiguration of infrastructure in the Revised Project Footprint Area (*Figure 12.34*), based on mitigation, avoids the loss of wetlands in Catchments A, C, D and E within the Afungi Project Site and limits the extent of potential impact of turbidity by protecting more wetland areas from construction activities. With the implementation of the above mitigation, impact intensity and magnitude will be reduced, and impact significance will be MINOR to MODERATE and NEGLIGIBLE during the construction and operational phases of the Project respectively.

Table 12.24 Impact of Increased Turbidity and Change in Sedimentation Patterns on Biological Features of Wetlands (Lacustrine and Estuarine)

	Without Mitigation	**Residual Impact (with Mitigation)**
Construction Phase		
Duration	Short term (long term for the estuaries)	Short term (long term for the estuaries)
Extent	Local	Local
Intensity	High	Low to Medium
Magnitude	**High**	**Low to Medium**
Likelihood	**Definite**	**Likely**
Significance	**MAJOR**	**MINOR to MODERATE**
Operational Phase		
Duration	Temporary	Temporary
Extent	Local	Local
Intensity	Low	Low
Magnitude	**Low**	**Low**
Likelihood	**Unlikely**	**Unlikely**
Significance	**NEGLIGIBLE**	**NEGLIGIBLE**

12.10 VEGETATION

12.10.1 Overview

This section assesses the potential impacts from Project activities on vegetation and subsequent habitat fragmentation, as well as the disturbance of ecologically sensitive areas within the Afungi Project Site. Project activities

likely to result in adverse impacts on the vegetation are predominantly related to the construction phase (site clearance). Secondary impacts caused by removal of vegetation, such as impacts on soils and fauna (herpetofauna, avifauna and mammals), are covered below and are not considered further in this section.

12.10.2 Impact of Site Clearance on Loss and Fragmentation of Habitats

Impact Assessment

The Afungi Project Site comprises a diversity of vegetation types, which are supported by a moisture regime dependent on surface and subsurface water flow from higher elevations, through a network of wetlands, *dambos* and mangroves to where it eventually reaches the sea. The spatial arrangement of different Vegetation Units is dependent upon the availability of the subsurface water flow. Seven distinct vegetation units have been identified.

Of the seven vegetation units, the marshland and wetland vegetation units 2 (1) and 5 (2) respectively are considered to be of Very High sensitivity, due to their high ecological functioning and influence in ecosystem functionality on various other vegetation units. Much of the vegetation in the Afungi Project Site has been transformed (eg for subsistence agriculture) and, although species composition has been maintained in some of the Vegetation Units, the structure and density varies within each. This variation can be attributed to the extent of vegetation clearance for cultivation. Slash-and-burn practices are frequently carried out.

The site clearance activities will result in the direct loss of vegetation, which will cause the fragmentation of habitats. Although no Red Data plant species were encountered during the terrestrial ecology surveys conducted in December 2011 and March 2012, they may occur (3). Identification of many of these rare plant species is dependent on examination of the flowers or inflorescences (December to March), and some species may flower outside the periods when surveys were conducted in the Afungi Project Site.

Impacts from vegetation clearance will occur onsite during the construction phase and will be long-term to permanent in duration. The intensity of the impact depends on the type, sensitivity and amount of vegetation to be cleared. The impact will be lower in already disturbed habitats and higher in habitats more sensitive to change. The vegetation units and habitats identified are widespread outside the Afungi Project Site and in the surrounding region (including in the region from Mtware in Tanzania and down to the Quirimbas National Park (4)). As shown in *Figure 12.35*, 710ha (20 percent) of the 3,600ha

(1) The *Rhizophora mucrunata–Ceriops tagal* Short Closed Marshland.
(2) The *Cyperus prolifer* Short Closed Wetlands.
(3) Red Data Plant species were observed during the Surface Water Ecology field surveys, and impacts to these are discussed in *Section 12.9*.
(4) This is part of the Eastern Africa Marine Ecoregion (EAME), as defined by WWF.

to be cleared contains High and Very High sensitivity vegetation types. The site clearance activities are expected to result in further fragmentation or possibly the complete loss of these areas. Given that all these vegetation types currently show some degree of fragmentation and modification by human activities, impact intensity is considered to be Medium.

The impact is likely to be significant onsite in the short or medium term as some, if not all, ecological features, structures and functions of the vegetation to be cleared within the Afungi Project Site will be lost. Given the abundance and integrity of the various habitat types in a regional context, the impact of vegetation loss within the Project Footprint Area is not expected to have an adverse effect in a regional context. Impact magnitude will therefore be Medium. With a definite likelihood, the impact significance of loss of vegetation and habitat fragmentation is expected to be MODERATE.

The degree of confidence in the assessment is High.

40°30'0"E 40°32'0"E 40°34'0"E 40°36'0"E

10°46'0"S 10°48'0"S 10°50'0"S 10°52'0"S

Palma

Palma Bay

Quitupo

Senga

Maganja

bing™

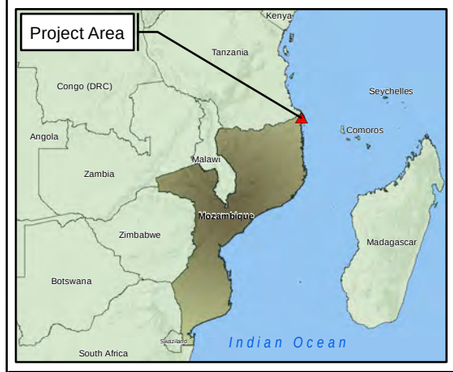
© Harris Corp, Earthstar Geographics LLC State of Michigan

Legend

- Villages / Settlements
- Local Roads
- Nearshore Components
- Onshore Project Footprint
- Afungi Project Site

Vegetation Sensitivity

- Very Low
- Low
- Medium
- High
- Very High



MAIN MAP SCALE:

0 1 2 3 Kilometers

N

TITLE:

Figure 12.35:
Vegetation Sensitivity Map - Onshore Project Footprint Area

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 50 000

DRAWING: Vegetation Sensitivity OPF.mxd

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Impacto Projectos e Estudos Ambientais

ERM

Projection: UTM Zone 37 S, Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
Enviro-Insight, 2012. Inset Map: Esri Data & Maps

SIZE: A3

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Mitigation Measures

The primary mitigation measure is to plan carefully the layout of the Project Footprint Area during the engineering design phase, and consider alternatives to minimise the required Project footprint and reduce the potential impact on High sensitivity areas. *Figure 12.36* illustrates the revised Project Footprint Area, which avoids as much of the High sensitivity areas as possible.

The following additional mitigation measures are proposed:

- The placement of Project infrastructure should be located on areas of Low to Medium vegetation sensitivity to the extent practicable.

- Very high and high sensitivity areas and protected tree species should be preserved to the extent possible through further design adjustment during FEED.

- Buffer zones will be established to prevent adverse impacts on adjacent sensitive areas.

- Environmental awareness training will include information related to the preservation of sensitive vegetation, and will be provided to all staff (as well as visitors and labourers).

- The Project will develop a site management strategy which will include the following measures to reduce impact on sensitive vegetation:

    - minimise removal of trees greater than 20cm diameter at breast height (DBH) to the extent practicable;

    - avoid disturbances to mangrove areas to the extent practicable; and

    - rehabilitate temporary-use areas as soon as practicable, using stockpiled topsoil and vegetation native to the area.

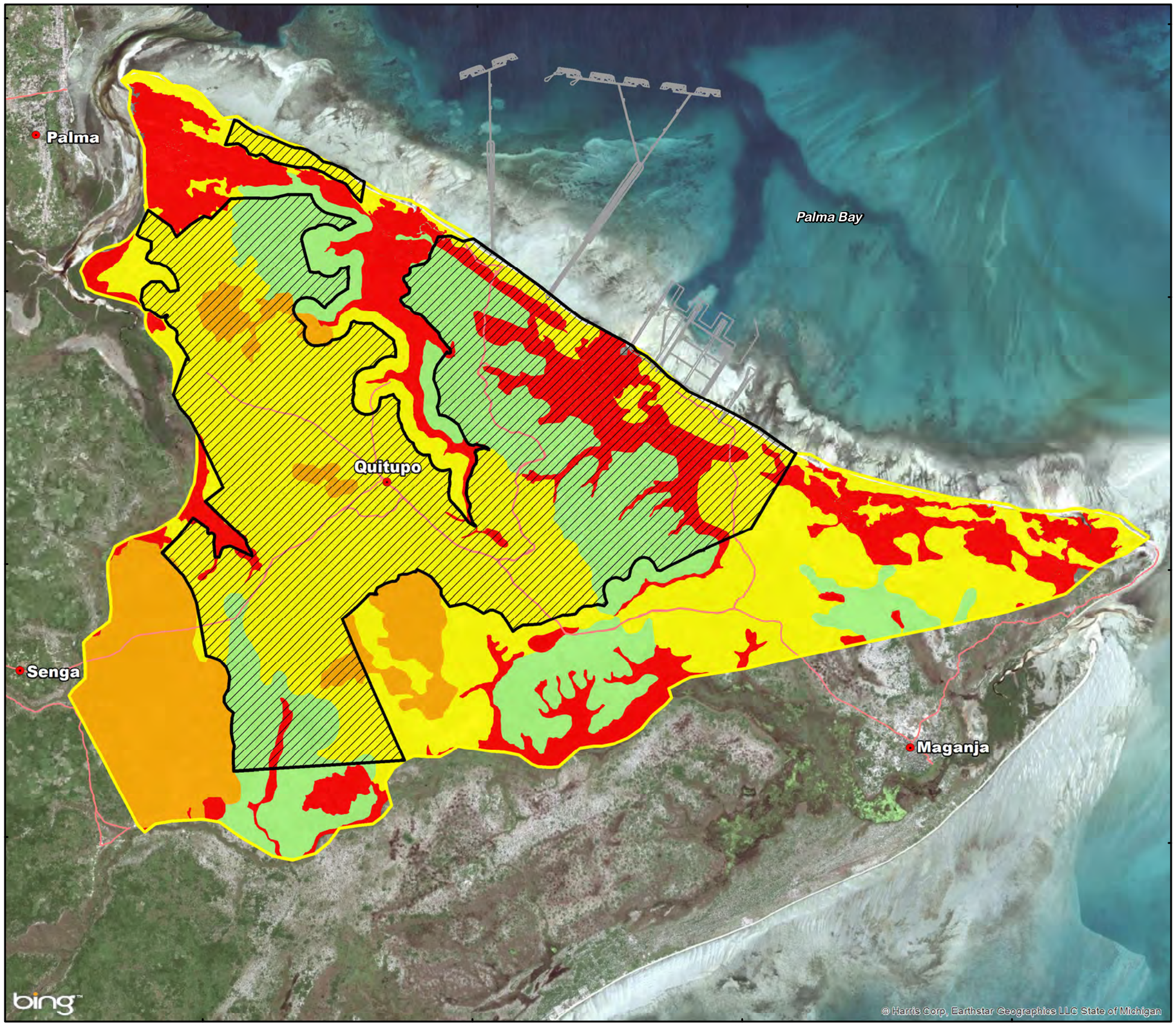
- Rehabilitate temporary-use areas using methods in accordance with the Decommissioning and Rehabilitation Plan (see *Annex F).*

Residual Impact

Impacts on vegetation derive from the direct land-take footprint from the physical presence of the development; however, the measures outlined above reduce this impact to ALARP. The Revised Project Footprint Area reduces the impact on areas identified as very high and high sensitivity habitats from 710ha to 500ha, thereby reducing the impact area by 210ha (*Figure 12.35*). With the implementation of the above control and mitigation measures, impact intensity and magnitude are reduced to Low, and thereby impact significance is likely to be reduced to MINOR.

Table 12.25 Impact of Site Clearance on Loss and Fragmentation of Habitat

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Long term to permanent	Long term to permanent
Extent	Onsite	Onsite
Intensity	Medium	Low
Magnitude	**Medium**	**Low**
Likelihood	**Definite**	**Definite**
Significance	**MODERATE**	**MINOR**

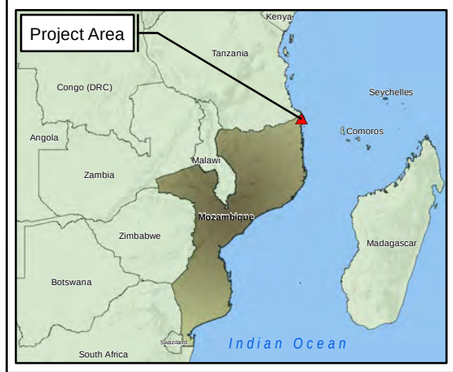


Legend

- Villages / Settlements
- Local Roads
- Nearshore Components
- Revised Project Footprint
- Afungi Project Site

Vegetation Sensitivity

- Very Low
- Low
- Medium
- High
- Very High



MAIN MAP SCALE:

0 1 2 3 Kilometers

N

TITLE:

Figure 12.36:
Reduced Impact on Sensitive Vegetation Communities - Revised Project Layout

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 50 000

DRAWING: Vegetation Sensitivity Revised OPF.mxd

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Projection: UTM Zone 37 S, Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
Enviro-Insight, 2012. Inset Map: Esri Data & Maps

SIZE: A3

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12.10.3 Impact of Invasion of Undesirable Plant Species on Ecological System Functions

Impact Assessment

Invasive plant species are those introduced deliberately or unintentionally into new environments outside their natural habitats, where they have the ability to establish themselves and out-compete native (indigenous) species and take over the new environments. According to the IUCN, invasive species represent the second most significant cause of species extinction worldwide after habitat destruction (1).

With the exception of cultivated trees such as cashew nut, coconut palm, mango and guava, few other alien trees occur in the Afungi Project Site. These species occur throughout the Afungi Project Site, with concentrations in villages, old settlements/households and newly settled areas. Settlement areas with associated agricultural practices are dominated by pioneer and undesirable plant species, such as devil's weed and castor oil bush. The presence of horsetail tree and sisal, found in Vegetation Unit 1, are indications of undesirable spread; active intervention may be required to control these invasive species.

In terms of alien and invasive aquatic floral species, although not observed within the Survey Area, water hyacinth (*Eichhornia crassipes*) has been found in southern Mozambique and is recorded to occur throughout the African continent. This species is highly invasive and could pose a problem within the wetland systems if introduced to the area.

Equipment and material imported or transported to the Afungi Project Site has the potential to contain alien plant species (or seeds), some of which may be invasive. Alien plant species may also be introduced for landscaping or rehabilitation, and have the potential to become invasive. Therefore, this impact could occur during all Project phases.

Disturbance of soil and/or the removal of established vegetation will increase the opportunity for invasive plants to germinate and establish. During the construction phase, when soil disturbance is at its highest, the intensity would be Medium with a local extent, as the potential spread of invasive plant species would not be confined to the Project Footprint Area. The duration of this impact would be long term. The planned disturbance of soils and natural vegetation will provide the opportunity for alien and invasive plants to become established, therefore making the potential for this impact Likely. The magnitude of the impact will be Medium for the construction phase. The resultant impact significance for these Project phases is expected to be MODERATE.

(1) See http://www.iucn.org/about/union/secretariat/offices/iucnmed/iucn_med_programme/species/invasive_species/.

During the operational phase, it is expected that the intensity will be reduced to Low. While no significant soil alterations are expected during operations, the establishment of alien/invasive plant species remains Likely, as there is still potential for these to be spread inadvertently by vehicle traffic or the import of materials. The magnitude of the impacts will be reduced to Low, but impacts are still Likely. The impact significance is therefore assessed as NEGLIGIBLE.

The degree of confidence for this impact is High.

Mitigation Measures

The mitigation measures proposed below will be most effective if established during the construction phase, as they will serve to reduce the likelihood of establishing and spreading alien/invasive species. The Project will implement procedures to control alien invasive plants. These procedures will be carried out through all phases of the Project.

- A monitoring programme will be implemented throughout the life of the Project to control alien/invasive plant species within areas under Project control, with special attention given to devil's weed, castor oil bush, horsetail tree and sisal. A qualified botanist should be contracted to conduct regular site surveys for non-native floral species, as part of this programme.

- Should monitoring indicate the spread of invasive species, *in situ* control and eradication measures will be implemented.

- All vehicles and equipment entering the Project from outside Palma District prior to revegetation should be washed before leaving their departure points, to remove vegetative material and seeds from alien/invasive plant species.

- Landscaping and rehabilitation should be restricted to the use of indigenous species and species that are known to be non-invasive in tropical climates in accordance with the Projects landscaping plan.

Residual Impact

The above mitigation measures will likely reduce the intensity and likelihood of establishing or spreading alien/invasive species. The residual impact significance is likely to be NEGLIGIBLE with the implementation of the proposed mitigation measures.

Table 12.26 Impact of Invasion of Undesirable Plant Species on Ecological System Functions

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Long term	Long term
Extent	Local	Local
Intensity	Medium	Low
Magnitude	**Medium**	**Low**
Likelihood	**Likely**	**Unlikely**
Significance	**MODERATE**	**NEGLIGIBLE**
Operational Phase		
Duration	Long term	Long term
Extent	Local	Local
Intensity	Low	Low
Magnitude	**Low**	**Low**
Likelihood	**Likely**	**Unlikely**
Significance	**NEGLIGIBLE**	**NEGLIGIBLE**

12.11 HERPETOFAUNA

12.11.1 Overview

Project activities likely to result in adverse impacts on herpetofauna (reptiles and amphibians) are predominantly associated with the construction phase; however, impacts may occur during the operational phase. The primary impacts identified include:

- loss of habitat;
- displacement and disturbance;
- water quality; and
- indirect effect of in-migration of people.

12.11.2 Impact of Site Clearance on Sensitive Herpetofauna Habitat

Impact Assessment

As described in *Chapter 8*, the Afungi Project Site consists of several areas regarded as sensitive herpetofauna habitat. Of the approximately 3,600ha of vegetation that will be removed during site clearance, approximately 835ha is classified as being of High or Very High sensitivity habitat for herpetofauna.

The fresh-water wetlands are of integral importance to the functionality of the herpetofauna community, and are therefore considered as their most sensitive habitat type. These systems provide active breeding opportunities for amphibians and are used for more than half the year. Additionally, wetlands are an integral driver of the wider ecosystem, due to the productivity of amphibian communities. Reptile species, such as crocodiles and southern African pythons, are reliant on aquatic environments and are typically restricted to fresh-water wetlands, except during migration. Removal of these

wetlands has the potential to adversely affect such reptiles, as well as other vertebrate faunal groups reliant on these areas for foraging.

The contiguous trees found adjacent to the wetland areas, together with the fresh-water wetlands themselves, provide essential ecological functions (such as breeding, shelter and foraging habitat) and exhibit high herpetofauna species diversity and abundance. The relationship between these sensitive habitat types and the Project Footprint Area is illustrated in *Figure 12.37.*

A potentially new species of Acontine skink was discovered within the Project Footprint Area during the field investigations. Evidence gathered to date suggests that this species is new to science. Therefore, the distribution or habitat dependence of this potentially novel species is not known, although three of the four observed specimens were found on the banks of the fresh-water wetlands. Therefore, it is currently thought that this is their preferred habitat type. The small size and fossorial habits of the species suggest a potentially very small geographic range, although this is speculative at present and requires more detailed investigation to inform management decisions.

Site clearance activities during the construction phase will result in the loss or fragmentation of approximately 835ha of these sensitive habitat types within the Afungi Project Site. The loss of sensitive herpetofauna habitat is an onsite impact with a permanent duration. Aerial imagery and field observations of the broader Study Area indicate similar habitat types are widespread throughout the region. Additionally, field surveys indicate that the density and species composition of herpetofauna in adjacent wetland areas (of similar value) are comparable to those within the Project Footprint Area. While there are similar habitat types (in the immediate vicinity and surrounding region) with a likely similar array of herpetofauna species, the presence of the potentially new skink species means that the Precautionary Principle (1) should be followed. A Medium to High intensity impact is thus anticipated with a concomitant Medium to High magnitude. Coupled with a Likely probability, the significance of this impact is expected to range from MODERATE to MAJOR. The degree of confidence in the assessment is Low to Medium, given the uncertainty around the distribution of the potentially new skink species.

(1) The Precautionary Principle states that when an activity may cause some threat or harm to the public or the environment and there is a lack of scientific consensus on its extent, general precautionary measures should be taken.

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10°46'0"S
10°48'0"S
10°50'0"S
10°52'0"S

Palma
Quitupo
Senga
Maganja
Palma Bay

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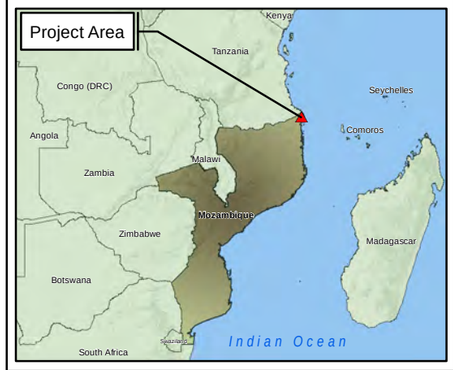
Legend

- Villages / Settlements
- Local Roads
- Nearshore Components
- Onshore Project Footprint
- Afungi Project Site

Herpetofauna Sensitivity

- Negligible
- Low
- Low-Medium
- Medium
- High
- Very High



MAIN MAP SCALE:

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TITLE:

Figure 12.37:
Herpetofauna Sensitivity Map - Onshore Project Footprint Area

CLIENT:

Anadarko Moçambique Área 1, Lda
eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
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DRAWING: Herpetofauna Sensitivity OPF.mxd
REV: A

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Projection: UTM Zone 37 S, Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation. Enviro-Insight, 2012. Inset Map: Esri Data & Maps

SIZE: A3

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Mitigation Measures

Impacts are directly linked to the site clearance activities associated with the construction phase of the Project. While the habitat will remain lost to herpetofauna through the operational phase, no additional habitat loss is expected during this phase of the Project. *Figure 12.37* illustrates sensitive areas relative to the base case Project Footprint Area, and *Figure 12.38* shows the revised layout, which avoids as much of the sensitive areas as possible.

- Minimise site clearance activities within areas of Very High and High herpetofauna sensitivities to the extent practicable.

- Locate Onshore Project infrastructure in areas of Low herpetofauna sensitivity to the extent practicable.

- Establish temporary construction and laydown sites in areas of Low herpetofauna sensitivities.

- Herpetologist to undertake additional field studies prior to construction to determine the habitat extent for the potentially new species of Acontine skink. The results of these field surveys are to be considered prior to site clearance activities.

- Establish buffer zones to prevent adverse impacts on adjacent sensitive areas. These buffer areas will be barricaded to restrict the movement of construction equipment into adjacent sensitive areas.

Residual Impact

The Revised Project Footprint Area (*Figure 12.38*) reduces the total area of impact on very high and high sensitivity herpetofauna habitat from 835ha to approximately 512ha, thereby reducing the footprint of impact on sensitive herpetofauna habitat (primarily wetlands and surrounding habitat) by approximately 323ha. This change in layout avoids disturbance of the areas in which the potentially new species of Acontine skink was discovered. No individuals were found during a survey in March/April 2012, despite intensive searching, and additional field studies are planned for mid to late 2013 to determine the habitat extent for this species. Field studies will be conducted within the Project Footprint Area, Afungi Project Site, and in similar habitats outside the Afungi Project Site in an effort to determine the range of this species. The result of these field surveys will be available in time to influence the site clearance activities.

The above mitigation measures will reduce the magnitude of the impact to Low. Thus, a MINOR residual impact is expected.

Table 12.27 Impact of Site Clearance on Sensitive (Areas of High and Medium–High) Herpetofauna Habitat

	Without Mitigation	**Residual Impact (with Mitigation)**
	Construction Phase	
Duration	Permanent	Permanent
Extent	Onsite	Onsite
Intensity	Medium to High	Low
Magnitude	**Medium to High**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MODERATE to MAJOR**	**MINOR**

40°30'0"E 40°32'0"E 40°34'0"E 40°36'0"E

10°46'0"S 10°48'0"S 10°50'0"S 10°52'0"S

Palma

Palma Bay

Quitupo

Senga

Maganja

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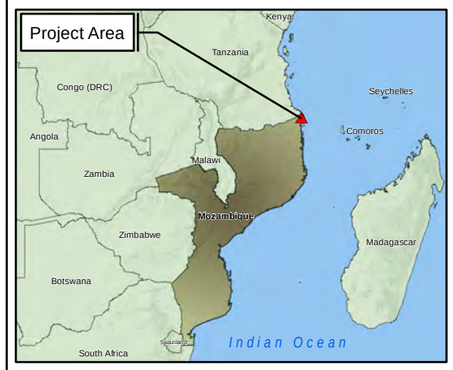
Legend

- Villages / Settlements
- Local Roads
- Nearshore Components
- Revised Project Footprint Area
- Afungi Project Site

Herpetofauna Sensitivity

- Negligible
- Low
- Low-Medium
- Medium
- High
- Very High



MAIN MAP SCALE:

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TITLE:

Figure 12.38:
Reduced Impact on Sensitive Herpetofauna Habitat - Revised Project Layout

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Projection: UTM Zone 37 S, Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
Enviro-Insight, 2012. Inset Map: Esri Data & Maps

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12.11.3 Impacts of Mortality, Displacement and Disturbance of Herpetofauna Species from Project Activities

Impact Assessment

Herpetofauna mortality, displacement and disturbance is expected to occur during the construction and operational phases of the Project. The operational phase is longer in duration; however, fewer impacts are likely during this phase as the vast majority of the resident herpetofauna are expected to have been displaced by this stage.

Potential impacts are expected to result from two main activities: the development of access roads and similar linear structures, and site preparation earthworks.

The development of access roads and linear structures has the potential to create habitat fragmentation and alter natural dispersal routes for herpetofauna. In such cases, the areas cleared of vegetation act as a barrier to migration for certain herpetofauna (eg chameleons will rarely cross open ground and, if they do, they are very vulnerable to predation). In addition, the creation of linear features (the widening of existing roads, and new roads within the Project Footprint Area) has the potential to create habitat fragmentation as a result of vegetation clearance. Habitat fragmentation occurs most easily through long linear disruptions of the landscape, such as:

- roads;
- pipelines;
- fencing;
- trenches;
- electricity lines and associated services; and
- other long infrastructure eg building walls.

Because these structures will be installed during the construction phase and remain in place for the operational phase, there is little expected difference in impacts between the phases. However, trenches are expected during the construction phase only.

Species composition is likely to change on the edge or extents of cleared areas. Connectivity between habitats is essential for natural ecological processes to proceed. Herpetofauna have poor dispersal abilities and require connected habitats for effective migration. In addition, vegetation clearing is likely to result in direct herpetofauna mortalities, due to physical injuries and potentially increased predation as vegetation cover is removed. The site clearance and preparation activities will displace and/or disturb herpetofauna during the construction phase and potentially result in the mortality of some individuals. This direct negative impact will occur onsite, be of short-term duration and have a High intensity. This impact will definitely occur and its magnitude is expected to be Medium, leading to a MODERATE impact significance.

Operational impacts are anticipated to be less intrusive, since any additional construction activities (similar to those listed above) will occur on areas previously disturbed. Operational phase activities expected to result in the disturbance or displacement of herpetofauna will likely result from equipment or activities that generate noise or light, particularly within the LNG Process Area. The disturbance caused during operational activities is expected to occur at the level of the individuals occurring in the vicinity of the disturbances. These individuals are likely to either become habituated to the disturbance or vacate the area (ie become displaced).

The extent of the impact during operational activities would be onsite. The duration is expected to be long term and, regardless of potential habituation, the intensity is likely to be Low. Therefore, a Low magnitude impact is expected with a Likely probability of occurrence, resulting in an impact significance of MINOR.

Mitigation Measures

Minimising herpetofauna mortality, disturbance and displacement is directly linked to maintaining habitat functionality and connectivity. The mitigation measures recommended to minimise impacts on ecologically sensitive areas will likewise reduce impacts on the mortality and displacement of herpetofauna species from the Project Area. Therefore, the mitigation measures provided below are intended to be implemented in conjunction with those related to preserving sensitive habitat types. The following mitigation measures are recommended for the Project construction phase:

- As part of induction training, the Project will develop and provide Environmental Awareness Training. This training will include information related to the herpetofauna importance of the area, and will be provided to all staff (as well as visitors and labourers).

- The Project will develop a site management strategy. This strategy will include the following measures to reduce herpetofauna impact:

    - clearing of vegetation will be carried out in a systematic fashion. It is recommended that this be carried out from the coastline towards the interior (from north-east to south-west). This will serve to displace herpetofauna populations from the Project Footprint Area towards potentially suitable habitats inland, and decrease the likelihood of injury to individuals; and

    - during site clearance, retain a dispersal network of undisturbed vegetation connecting to similar habitats outside the Project Footprint Area, to provide a corridor for herpetofauna species to disperse off-site.

- Mitigation measures will strive to increase the permeability of linear features. The mitigation of linear disruptions depends largely on the engineering design of each structure, and general mitigation measures are provided for each.

    - Roads: safe permeability can be increased by the use of underpasses or culverts. Culverts to be located close to drainage channels and wetlands to the extent practical.

    - Pipelines: these should either be raised approximately 50cm above the ground (allowing herpetofauna to move unhindered underneath) or should be buried at least 30cm below ground (this allows fossorial herpetofauna to move over the pipeline).

    - Fencing: if fencing is to be electrified, the lowest electrified strand should be at least 20cm above the ground surface to avoid electrocutions.

    - Trenches: excavated trenches should be left open for as short a time as possible to avoid habitat fragmentation. Open excavated trenches should have periodic breaks in one slope, with an angle of less than 45° to allow animals that might have fallen in to climb out.

- Restrict construction personnel to the designated construction area to minimise disturbance to herpetofauna species in adjacent areas.

- Enforce vehicle speed limits to reduce the likelihood of herpetofauna mortality and disturbance.

In conjunction with the mitigation measures suggested for the construction phase, the following mitigation measures are recommended for the operational phase of the Project:

- Reduce exterior lighting to that necessary for safe operation, and implement operational strategies to reduce spill light. This will reduce the likelihood of attracting insects which, in turn, attract herpetofauna.

- Use non-UV lights where possible, as light emitted at one wavelength has a Low level of attraction to insects.

Residual Impact

The Revised Project Footprint Area reduces the extent of disturbance within the areas of High herpetofauna sensitivity, thereby reducing the extent of herpetofauna displacement as valuable habitat is salvaged. The implementation of the construction phase mitigation measures is expected to reduce the intensity and likelihood to Low and Likely respectively. Therefore, the residual impact is expected have a Low magnitude, resulting in an impact significance reduced to MINOR.

Similarly, the proposed operational phase mitigation measures are expected to reduce the likelihood of adverse impacts, resulting in a residual impact significance of NEGLIGIBLE.

Table 12.28 Impacts of Mortality, Displacement and Disturbance of Herpetofauna Species from Project Activities

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Short term	Short term
Extent	Onsite	Onsite
Intensity	High	Medium
Magnitude	**Medium**	**Low**
Likelihood	**Definite**	**Likely**
Significance	**MODERATE**	**MINOR**
Operational Phase		
Duration	Long term	Long term
Extent	Onsite	Onsite
Intensity	Low	Low
Magnitude	**Low**	**Low**
Likelihood	**Likely**	**Unlikely**
Significance	**MINOR**	**NEGLIGIBLE**

12.11.4 Impact of Water Pollution on Herpetofauna

Impact Assessment

Erosion and resultant sedimentation as well as infiltration of fertilisers could result in changes to water quality, which affects herpetofauna. Amphibians are particularly sensitive to changes in water quality due to their semi-permeable skin. In addition, the eggs (laid in water) and tadpoles are also very sensitive to water pollution, which can impair normal development or cause death. Because amphibians form a large part of the diet of predacious vertebrates, any bioaccumulation of toxins could potentially be spread through the trophic levels of the food chain.

Chronic release or the leaching of fertilisers into wetland areas (operational phase) and sedimentation (construction phase) are likely to affect wetlands during the construction phase and operational phase. Fertilisers increase nutrients, resulting in eutrophication, which can lead to the increased susceptibility of amphibians to parasites and pathogens. It can also create anoxic conditions in the water, preventing amphibian eggs from developing and can therefore decrease the overall breeding success of the taxa.

Industry-standard measures to minimise erosion and manage run-off will be applied during construction and operations. Fertiliser leachate will be confined to a small area as the site slopes towards Palma Bay, limiting the extent of any fertiliser plume into adjacent wetlands. Therefore, any impacts are expected to be onsite. A short-term to medium-term duration is expected. The intensity of this potential impact could reasonably be expected to be Low

to Medium. The impact is Likely, and its magnitude is expected to be Low to Medium. A MINOR to MODERATE impact is expected.

Mitigation Measures

Consequently, the mitigation measures recommended below are focused on preventing adverse impacts on areas adjacent to the Project Footprint Area, ie wetlands not planned on being infilled by the Project.

- Buffer zones will be established to prevent adverse impacts on adjacent wetlands and water bodies. These buffer areas will be clearly demarcated to restrict the movement of construction equipment or workers.

- Project infrastructure should be located outside wetland areas and natural drainage routes to the extent possible.

- Establish erosion control measures (including for access roads) to prevent the sedimentation of wetlands and water bodies.

- Fuel and chemical storage and transfer will be contained within bunded areas, and spill kits will be kept in storage areas and consistent with Good International Industry Practice.

- As soon as practicable, revegetate temporary use areas adjacent to wetlands and water bodies, to reduce the likelihood of sedimentation impacts.

The following mitigation measures are recommended for the operational phase of the Project:

- Use of slow-release fertilisers for landscaping or revegetation in line with the Project's landscaping plan.

- Fuel and chemical storage and transfer will be contained within bunded areas, and spill kits will be kept in storage areas in accordance with Good International Industry Practice.

Residual Impact

The implementation of the above mitigation measures can be expected to reduce the intensity and magnitude of this potential impact to Low during construction and operations. Thus, a MINOR significance residual impact is expected.

Table 12.29 Impacts of Water Pollution on Herpetofauna

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Short term	Short term
Extent	Onsite	Onsite
Intensity	Low to Medium	Low
Magnitude	**Low to Medium**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MINOR to MODERATE**	**MINOR**
Operational Phase		
Duration	Short term	Short term
Extent	Onsite	Onsite
Intensity	Low to Medium	Low
Magnitude	**Low to Medium**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MINOR to MODERATE**	**MINOR**

12.11.5 Indirect Impacts Related to the In-migration of People on Herpetofauna

Impact Assessment

An influx of people is expected into the area surrounding the Project and Afungi Project Site, due to the ease of access to natural resources (road network) and the possibility of obtaining jobs. This is an indirect impact of the Project, which may contribute to several of the impacts already discussed above. The use of natural resources is currently occurring in the area, although at relatively low levels due to low human population densities. However, the potential influx of people can reasonably be expected to increase the intensity of use and exploitation.

Adverse impacts on the resident herpetofauna can be expected through habitat loss and fragmentation, due to the establishment of new settlements and agricultural fields outside of the Afungi Project Site. Mortality, displacement and disturbance are also likely to occur, due to increased traffic on the roads, hunting and land (habitat) alteration. Herpetofauna densities may potentially be reduced, resulting in reduced breeding success and depleted local populations.

Activities anticipated to have an adverse impact on the surrounding herpetofauna communities associated with the influx of people include:

- Bush fires: these can occur accidentally from cooking fires or cigarette discards and/or intentionally to clear land for agriculture, and may result in habitat destruction and/or fragmentation.

- Clearing of vegetation: for agricultural lands, firewood collection and felling of hardwood trees for economic gain. These actions may also result in habitat destruction and/or fragmentation.

- Subsistence hunting and poaching: poorer families will supplement their protein requirements with bush meat, eg large reptiles such as pythons and crocodiles. Using herpetofauna for traditional medicine or for trading (skins) is also a possibility.

- Killing of herpetofauna due to superstitious beliefs: many snakes may be killed on sight, despite the beneficial function of several species in controlling rodent populations.

- Water pollution: poor sanitation may result in eutrophication and pollution of the surrounding water sources.

The staffing requirements for the construction phase presents the risk of an influx of a large number of people being drawn to the surrounding area (local workers may bring families, and traders may be drawn to supply goods to the workforce, etc).

While the population influx in likely to peak during the construction phase of the Project, the duration of the impacts is likely to carry through the life of the Project. In some cases, this potential effect of population influx may be permanent, because even after Project closure, a proportion of people may remain in the area. The extent of this impact is expected to be local with a Medium intensity; therefore, a Medium to High magnitude of impact is predicted. This population influx will be difficult to mitigate or manage in areas outside the direct control of the Project. An influx of people will likely occur to fulfil the labour requirements of the Project. This impact, therefore, is of MAJOR significance.

During the operational phase of the Project, the workforce will decline to a nominal population. Therefore, it is likely that the intensity of this potential impact would be reduced to Medium, and a Medium magnitude could be expected. However, the potential for adverse impact remains Likely; therefore, the operational phase impact significance is assessed as MODERATE.

The degree of confidence for this impact is Moderate, as it assumes a worst-case scenario.

Mitigation Measures

- The Project will undertake a Project Induced In migration Management (PIIM) Study to address environmental and social issues related to anthropogenic encroachment.

- It is recommended that a mobile fire control unit with trained staff be available to extinguish brush fires rapidly in the vicinity of the Project, to minimise potential adverse impacts on habitats from uncontrolled fires.

- It is recommended that the Project assists with the construction and maintenance of sanitation facilities for local settlements, to reduce the likelihood of water pollution.

Residual Impact

The undertaking of the Project Induced In migration Management (PIIM) Study, in conjunction with the implementation of the mitigation measures described above, will likely reduce the intensity of impact to Low. While adverse impacts of anthropogenic encroachment remain Likely, the magnitude can be expected to be reduced to Medium. The residual impact significance will be reduced to MODERATE during the construction phase. Similarly, these mitigation measures can be expected to reduce the intensity of impact to Low during the operational phase, resulting in a Medium to Low magnitude. Therefore, the resulting impact significance is expected to be MINOR to MODERATE during the operational phase.

Table 12.30 Indirect Impacts Related to the In-migration of People on Herpetofauna

	Without Mitigation	**Residual Impact (with Mitigation)**
	Construction Phase	
Duration	Long term	Long term
Extent	Local	Local
Intensity	High	Low
Magnitude	High	Medium
Likelihood	Likely	Likely
Significance	**MAJOR**	**MODERATE**
	Operational Phase	
Duration	Long term	Long term
Extent	Local	Local
Intensity	Medium	Low
Magnitude	Medium	Low to Medium
Likelihood	Likely	Likely
Significance	**MODERATE**	**MINOR to MODERATE**

12.12 AVIFAUNA

12.12.1 Overview

This section provides a description of the potential impacts the proposed Project is likely to have on the avian habitat and the local avifaunal community. Project activities likely to result in adverse impacts on the avian habitat and community are predominantly related to the construction phase; however, additional impacts may occur during the operational phase. The main avifaunal impacts identified include:

- loss of habitat;
- displacement and disturbance;
- disruption of migration and flyway corridors; and
- effects of anthropogenic encroachment.

12.12.2 Impact of Site Clearance Activities on Sensitive Avian Habitat

Impact Assessment

As described in *Chapter 8*, the Afungi Project Site consists of some areas regarded as sensitive avifauna habitat (see *Figure 12.39*). The proposed site clearance activities associated with early works will involve the removal of approximately 3,600ha of vegetation, of which approximately 835ha is classified as High or Medium–High sensitivity in terms of avifaunal habitat. Vegetation clearance will result in the loss or fragmentation of these sensitive habitat types.

Areas of high avian sensitivity are largely associated with estuarine salt marshes, fresh-water wetlands and large intact forests. Most of these systems represent ecosystems with high connectivity with important bird flight paths or high bird diversities, while providing suitable habitat for a number of threatened or rare species. Areas of Medium–High avian sensitivity include the intertidal zone and mangrove forests. These areas provide some degree of connectivity with other ecological systems or ecosystems with intermediate levels of species diversity, but may include potential ephemeral habitat for threatened species.

These habitat types are widespread outside the Afungi Project Site in a regional context, as the region from Tanzania and down to the Quirimbas National Park is largely rural in nature and relatively undisturbed. Throughout this region, fresh-water wetlands act as important ecological links and resting points for bird species. Salt marshes and mangroves serve as breeding habitat and feeding grounds. The coastal intertidal zone is an important wintering feeding area for high numbers of Palaearctic waders and shorebird species.

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10°46'0"S

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10°50'0"S

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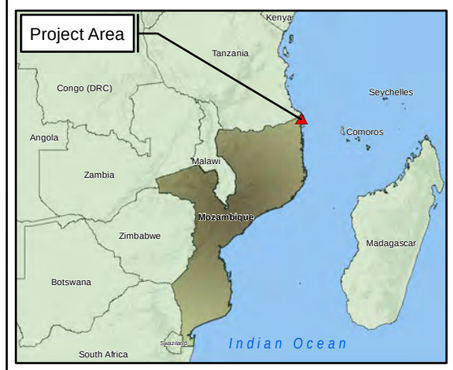
Legend

- Villages / Settlements
- Local Roads
- Nearshore Components
- Onshore Project Footprint
- Afungi Project Site

Avifauna Sensitivity

- Low
- Medium
- Medium-High
- High



MAIN MAP SCALE:

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Figure 12.39: Avifaunal Habitat Sensitivity Map - Onshore Project Footprint Area

CLIENT:

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While the key habitat types are fairly ubiquitous in the region, it should be noted that five IUCN-listed species are known to occur within the Afungi Project Site. Of these, the Madagascar pond heron (Endangered) and the wattled crane (Vulnerable) are likely to be susceptible to site clearance, due to a high degree of reliance on these specific habitat types (habitat fidelity). These species occupy large home ranges and occur over large areas of similar habitat. They are, therefore, at a lower risk of adverse impacts resulting from site clearance. In addition, the intertidal zone at Afungi Peninsula is an important wintering ground for a large percentage of the global population of crab plovers (32 percent, as mentioned in *Chapter 8*). Though listed as Least Concern, the concentration of this species is noteworthy. The Project Footprint Area provides habitats for several biome-restricted species: five bird species with Zambian affinities, and 13 with affinities to the East African coastal woodlands (Parker, 2001). However, the majority of these species are widespread and common throughout the region.

The loss of the avifauna habitat is an onsite impact and will occur during the construction phase. The impact is expected to be long term to permanent in duration. The intensity of the impact depends on the overall ecological function of the habitat type lost and its respective species composition, and on the availability of similar habitat types outside the impacted area. Due to the lack of robust data for adjacent areas (1), uncertainties exist relating to the availability of similar habitat outside the Project Footprint Area. A conservative approach has been applied in assessing the intensity of this impact as High, particularly for the crab plover, since such a large percentage of the global population will be impacted by the presence of the Near Shore Project infrastructure.

A Medium to High magnitude impact is expected, coupled with a definite likelihood and, therefore, the significance of this impact is MODERATE to MAJOR. The degree of confidence in the assessment is Medium.

Mitigation Measures

These impacts are directly linked to the site preparation activities associated with the construction phase of the Project. As such, the mitigation measures outlined below are mainly relevant to the construction phase.

- Minimise Project Footprint Area within areas of High avifaunal sensitivities to the extent practicable.

- Establish temporary construction and laydown sites in areas of Low avifaunal sensitivities.

- Buffer zones will be established to prevent adverse impacts on adjacent sensitive areas. These buffer areas will be clearly demarcated to restrict

(1) Avifauna habitat identification was limited to the Afungi Project Site and immediate surrounds.

the movement of construction equipment and workers into adjacent sensitive areas.

Residual Impact

The recommended mitigation measures will be applied to the extent practicable. The Revised Project Footprint Area (*Figure 12.40*) reduces the total area of High and Medium–High sensitivity avian habitat from 835ha to 620ha, thereby reducing the footprint of impact on sensitive avian habitat by 215ha. As an adjacent High sensitivity avian habitat will be preserved, these mitigation measures are anticipated to reduce the intensity of the potential impact to Low to Medium. The reduction of the Project Footprint Area reduces the likelihood of adverse impact to Likely, and the magnitude of the residual impact is expected to be Low to Medium. Following mitigation, the significance of the residual impact is expected to be MINOR to MODERATE.

Table 12.31 Impact of Site Clearance Activities in Sensitive (Areas of High and Medium–High) Avifaunal Habitat

	Without Mitigation	**Residual Impact (with Mitigation)**
	Construction Phase	
Duration	Long term to permanent	Long term to permanent
Extent	Onsite	Onsite
Intensity	High	Low to Medium
Magnitude	**Medium to High**	**Low to Medium**
Likelihood	**Definite**	**Likely**
Significance	**MODERATE to MAJOR**	**MINOR to MODERATE**

40°30'0"E 40°32'0"E 40°34'0"E 40°36'0"E

10°46'0"S 10°48'0"S 10°50'0"S 10°52'0"S

Palma

Quitupo

Senga

Maganja

Palma Bay

bing™

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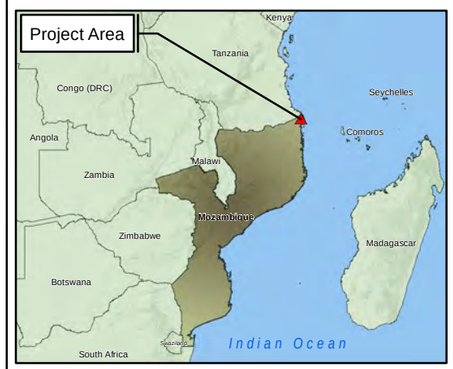
Legend

- Villages / Settlements
- Local Roads
- Nearshore Components
- Revised Project Footprint
- Afungi Project Site

Avifauna Sensitivity

- Low
- Medium
- Medium-High
- High



MAIN MAP SCALE:

0 1 2 3

Kilometers

N

TITLE:

Figure 12.40: Reduced Impact on Avifaunal Habitat-Revised Project Layout

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 50 000

DRAWING: Avifauna Sensitivity Revised OPF.mxd

REV: A

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Impacto Projectos e Estudos Ambientais

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SIZE: A3

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12.12.3 Impact of Project Activities on Sensitive Avian Species through Displacement and Disturbance

Impact Assessment

The disturbance of avifauna is inevitable during the construction and operational phases of a project of this scale and nature. Impacts will especially be significant near or in close proximity to breeding or roosting sites, or near large congregations of waterbirds. Since the loss of avifaunal habitat (see *Section 12.12.2*) will result in the direct displacement of its associated species composition, it is possible that a number of sensitive avian species will become displaced by the proposed Project. Species likely to be particularly affected will be habitat specialist species (eg Madagascar pond herons), those that occupy large home ranges (eg southern banded snake eagles) and gregarious species (eg crab plovers and waders).

Disturbances to birds during construction activities are likely to result from high ambient noise levels and the presence of mobile machinery (eg the operation of heavy construction equipment). Continuous noise may disrupt the normal behaviour of avian species (breeding, foraging), causing displacement away from the area. However, some bird species may eventually become habituated to these noise levels and resume normal behaviour. In some species, continuous noise may induce a high-stress environment and negative associations with a specific habitat, and this may cause the long-term disruption of breeding and foraging behaviour.

Larger avian species, such as the wattled crane and storks, will temporarily vacate an area when disturbed by Project activities. These species are primarily threatened by wetland degradation, often resulting from agricultural practices. However, this Project may have a similar effect on wetlands. Similarly, although site clearance activities will be minimal in areas of closed woodland habitat, the southern banded snake eagle (Near Threatened) may be temporarily displaced. However, this species is most common north of the Project Footprint Area where large, intact stands of closed woodland persist. In addition, the construction of the Near Shore Project infrastructure will result in disturbance to a small area (approximately 5ha) of the 38ha intertidal zone, and this will likely have an adverse impact on the crab plover.

These habitat types are not limited to the Project Footprint Area, and are readily found in the areas adjacent to the Afungi Project Site. Similar habitats are likely to be found across the regional coastline. For example, field observations indicate that the exposed coral found adjacent to Cabo Delgado Peninsula is an important high tide roosting site for crab plovers. Areas of closed woodland containing suitable habitat for the southern banded snake eagle are found nearby on Cabo Delgado Peninsula, and likely elsewhere in the region. These similar habitat types may be suitable to support avifauna displaced from the Project Footprint Area, although this has not be

investigated. The surrounding wetland areas could likely support crane and stork species displaced from the Onshore Project Area during construction.

The extent of displacement and disturbance to avifauna during construction could potentially be international, due to the high number of Palaearctic waders and other migratory species that use the area. The duration of the impact will be short term, as it is confined to the construction phase. The intensity of the impact depends on the availability of similar habitat types outside the impacted area. Should similar habitat types be present outside of the Afungi Project Site, intensity is likely to be Low. However, given the lack of definitive information regarding the presence of potentially suitable habitats in the vicinity of the Afungi Project Site, the intensity is conservatively estimated to be Medium. A Medium magnitude is expected, with a definite probability of occurrence. Therefore, the significance of the impact is expected to be MODERATE.

Avian disturbance during the operational phase will be less significant, as the major site clearance will be complete and noise levels will be reduced. Lighting from the LNG Facility and Near Shore Project infrastructure may result in the disturbance of species at night-time. Impacts are expected to affect individual birds occurring in the vicinity of the disturbance, rather than affecting birds at a population level. Individuals affected during operations are likely either to become habituated to the disturbance or vacate the area (ie become displaced). The extent of the impact is expected to be local during operations, as the disturbance is not expected to affect avian communities beyond 10km of the Afungi Project Site. The duration is expected to be long term and, regardless of potential habituation, the intensity is likely to be Low to Medium. Therefore, a Low to Medium magnitude is expected with a Likely probability of occurrence, resulting in an impact significance of MINOR to MODERATE. The degree of confidence for this impact is Medium.

Mitigation Measures

Minimising avian disturbance is directly linked to maintaining habitat functionality. Mitigation measures recommended to minimise impacts on ecologically sensitive areas will likewise reduce impacts on the displacement of sensitive avian species from the Afungi Project Site. Therefore, the mitigation measures provided below are intended to be implemented in addition to those in *Section 12.12.2*.

- Implement Environmental Awareness Training as part of induction training. This training will include information on identified sensitive avifaunal areas, and will be provided to all staff (as well as visitors and labourers).

- Clearing of vegetation will be carried out in a systematic fashion from the coastline towards the interior (from north-east to south-west). This will serve to displace avian populations from the Project Footprint Area

towards potentially suitable habitats inland, and decrease the likelihood of injury to individuals.

- Construction personnel and equipment will be restricted to the designated work areas to minimise the disturbance of avian species in adjacent areas.

- Enforce vehicle speed limits.

- Natural linear features (eg drainage lines) will be retained to the extent practicable to facilitate the movement of bird species.

- Reduce exterior lighting and implement operational strategies to reduce spill light. Exterior lighting could attract night-migrating bird taxa (eg African pitta) and could result in collisions with structures.

- Design lighting strategies that address or minimise items such as degree of spill light, use of 'up lights' and use of lights with red wavelengths. Down lighting is preferred as is lights with blue or green wavelength.

Residual Impact

The Revised Project Footprint Area reduces the impacts on areas of High avian sensitivity, thereby reducing the extent of avian displacement by protecting valuable habitat. The application of the mitigation measures during construction is expected to reduce the magnitude of impact to Low. This will be achieved by reducing the extent of the impact to local, and sequential site clearance activities will limit the duration of disturbance in any one area to temporary. The likelihood of adverse impacts occurring will be reduced to Likely during construction; therefore, the residual impact significance is expected to be reduced to MINOR.

Similarly, implementation of the proposed mitigation measures is expected to reduce the extent of impacts associated with the disturbance and displacement of avifauna to local, and the intensity to Low. Therefore, a Low magnitude is expected with a Likely probability of occurrence, resulting in a residual impact significance of MINOR.

Table 12.32 Impact of Project Activities on Sensitive Avian Species through Displacement and Disturbance

	Without Mitigation	**Residual Impact (with Mitigation)**
	Construction Phase	
Duration	Short term	Temporary
Extent	International	Local
Intensity	Medium	Low
Magnitude	Medium to High	Low
Likelihood	Definite	Likely
Significance	**MODERATE**	**MINOR**

	Without Mitigation	Residual Impact (with Mitigation)
Operational Phase		
Extent	Regional	Local
Duration	Long term	Long term
Intensity	Medium	Low
Magnitude	Low to Medium	Low
Likelihood	Likely	Likely
Significance	**MINOR to MODERATE**	**MINOR**

12.12.4 Disruption of Flyways, Migration Corridors and Off-site Avian Habitats by Project Activities

Impact Assessment

The fresh-water wetlands and mangrove forests found within the estuaries are used as movement corridors by birds to access foraging habitats and breeding sites. These areas are often used as stepping stones during seasonal migration. The ecological function of these habitat features plays a significant role in strengthening gene cohesion between different populations of the same species and emigrating individuals.

Activities during both construction and operation of the Project could affect wetlands and mangroves adjacent to the Afungi Project Site. Alterations to this off-site avifaunal habitat may result in increased intraspecies and interspecies competition for resources, and could prevent access to suitable seasonal breeding and/or foraging sites for some species. These potential impacts would likely be most prevalent during the operational phase, once the drainage systems have been altered and successional plant communities have transformed the habitat.

The extent of such impacts could potentially be regional, depending on the areas affected and the composition of migratory avian species reliant on the impacted habitat. The effectiveness of rehabilitation after closure of the Project will determine the duration of the impact. Therefore, the impact could be long term to permanent. While there are uncertainties regarding the avian species composition in the adjacent areas and overall ecological function of the potentially affected areas, the intensity of this impact is expected to be Low, given the sheer number of similar habitat types along that stretch of coastline. Thus, the magnitude of the impact is rated as Low. Coupled with a Likely probability of occurrence, a MINOR impact is expected.

The degree of confidence for this impact is Medium, due to uncertainties associated with species composition in the adjacent areas and the use of potentially affected areas off-site.

Mitigation Measures

Mitigation will be most effective if implemented during the construction phase to reduce the likelihood of future adverse impacts. Monitoring is

recommended during the construction phase to confirm the effectiveness of the mitigation measures stipulated below. Monitoring will serve as an early warning of successional changes to habitats resulting from altered natural drainage routes. The following mitigation measures are recommended:

- The construction of roads in wetland systems or through natural drainage routes will be avoided to the extent practicable. In the event that this is not practicable, the following mitigation measures will be implemented:
    - minimise and consolidate the number of crossings of natural drainage channels; and
    - minimise the width of roadways to that necessary for the safe transport of personnel and equipment.
- Project infrastructure will be located outside wetland areas and natural drainage routes to the extent possible.
- Establish erosion control measures as required to prevent the sedimentation of wetlands and natural drainage routes.
- Use slow-release fertilisers for landscaping or revegetation.
- Storage of fuel and chemicals will be contained within bunded areas, and spill kits will be kept in storage areas.

Residual Impact

The Revised Project Footprint Area reduces the disturbance to wetland areas and reduces the impacts of roads on natural drainage corridors. These mitigation measures are expected to reduce the intensity to Low, as natural functions and processes are not expected to be materially affected. These control measures also limit potential adverse impacts to a local extent. This results in a post-mitigation impact magnitude of Low, with an unlikely chance of occurrence. Therefore, the residual impact significance is expected to be reduced to NEGLIGIBLE.

Table 12.33 Disruption of, Flyways, Migration Corridors and Off-site Avian Habitats by Project Activities

	Without Mitigation	**Residual Impact (with Mitigation)**
	Construction Phase	
Extent	Regional	Local
Duration	Long term to permanent	Temporary
Intensity	Low	Low
Magnitude	**Low**	**Low**
Likelihood	**Likely**	**Unlikely**
Significance	**MINOR**	**NEGLIGIBLE**

12.12.5 Impacts of the In-migration of People on Avifauna

Impact Assessment

The construction of the Project will provide employment opportunities for the local community as well as for people from further afield. An influx of people into the area may potentially impact negatively on the surrounding avian habitat types through uncontrolled encroachment. An increase in population is likely to lead to significant negative pressures on natural resources (eg firewood collection, snaring and poaching). In addition, human environments bring alien and invader species, including feral dogs and cats. Feral animals are likely not only to compete with the local fauna for resources such as food and shelter, but will also prey on them. Adverse impacts on the resident avian community can be expected through habitat fragmentation or loss, due to the establishment of new settlements and agricultural fields. Displacement and disturbance of avifauna is also likely to occur, due to increased traffic on the roads. In the case of feral animals, predation is likely to increase. Avian densities may potentially be reduced, resulting in reduced breeding success and depleted local populations.

Adverse impacts from anthropogenic encroachment are expected to be most substantial during the construction phase, when in-migration is greatest. While the onset of population influx is likely to peak during construction, the duration of the impacts are likely to be long term, as they will carry through the life of the Project. The potential effect of population influx may be permanent because, even after Project closure, a proportion of people may remain in the area. Therefore, the extent would be local and the intensity of the impact may be Medium to High. The magnitude of such an impact is expected to be Medium to High, with a Likely probability of occurrence. The significance of the impact is, therefore, expected to range from MODERATE to MAJOR.

During the operational phase of the Project, the workforce population will decline. Therefore, it is likely that the intensity of this potential impact would be reduced to Medium, and a Medium magnitude impact could be expected. However, the potential for adverse impact remains Likely. Therefore, the operational phase impact significance is assessed as MODERATE.

The degree of confidence for this impact is Moderate, as it assumes worst-case scenarios for unconfined human settlement and uncontrolled reproduction rates for invasive and feral animals.

Mitigation Measures

- The Project will undertake a Project Induced In migration Management (PIIM) Study to address environmental and social issues related to anthropogenic encroachment.

- Mobile fire-fighting capabilities will be provided to minimise potential impact to habitats from uncontrolled fires.

Residual Impact

The undertaking of the Project Induced In migration Management (PIIM) Study in conjunction with the other mitigation measure described above will likely reduce the intensity of the impact to Medium. While adverse impacts of anthropogenic encroachment remain Likely, the magnitude can be expected to be reduced to Medium. The residual impact significance will be reduced to MODERATE during the construction phase. Similarly, these mitigation measures can be expected to reduce the intensity to Low during the operational phase, resulting in a Medium to Low magnitude impact. The resulting impact significance is expected to be MINOR to MODERATE during the operational phase.

Table 12.34 Impacts of the In-migration of People on Avifauna

	Without Mitigation	**Residual Impact (with Mitigation)**
	Construction Phase	
Duration	Long term	Long term
Extent	Local	Local
Intensity	Medium to High	Medium
Magnitude	**Medium to High**	**Medium**
Likelihood	**Likely**	**Likely**
Significance	**MODERATE to MAJOR**	**MODERATE**
	Operational Phase	
Duration	Long term	Long term
Extent	Local	Local
Intensity	Medium	Low
Magnitude	**Medium**	**Low to Medium**
Likelihood	**Likely**	**Likely**
Significance	**MODERATE**	**MINOR to MODERATE**

12.13 MAMMALS

12.13.1 Overview

This section assesses the potential impacts the Project may have on mammals and mammalian habitats. Project activities likely to result in adverse impacts to mammals are largely related to habitat loss and displacement, which are expected to occur during the construction phase. However, additional impacts may occur during the operational phase. The primary impacts identified include:

- loss of habitat;
- displacement and disturbance;
- habitat fragmentation; and
- effects of anthropogenic encroachment.

12.13.2 Impact of Habitat Loss on Mammalian Fauna

Impact Assessment

As described in *Section 8.10*, the Afungi Project Site consists of several areas classified as High sensitivity mammalian habitat. These include the permanent wetlands and drainage areas located within the Project Footprint Area. The wetlands tend to lead into canopy forest and/or grassy *dambos* and provide corridor linkages for mammals throughout the area. These areas are illustrated in red (High sensitivity) in *Figure 12.41* below. The proposed site clearance activities will remove approximately 3,600ha of vegetation, of which approximately 106ha of this area is classified as being of High sensitivity habitat for mammalian fauna.

40°30'0"E 40°32'0"E 40°34'0"E 40°36'0"E

10°46'0"S
10°48'0"S
10°50'0"S
10°52'0"S

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Quitupo
Senga
Maganja
Palma Bay

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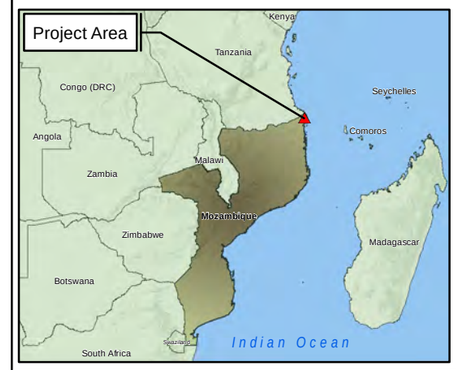
Legend

- Villages / Settlements
- Local Roads
- Nearshore Components
- Onshore Project Footprint
- Afungi Project Site

Mammal Sensitivity

- Low
- Medium
- High



MAIN MAP SCALE:

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Kilometers

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TITLE:

Figure 12.41:
Mammals Habitat Sensitivity Map - Onshore Project Footprint Area

CLIENT:

Anadarko Moçambique Área 1, Lda
eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 50 000

DRAWING: Mammal Sensitivity OPF.mxd

REV: A

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Projection: UTM Zone 37 S, Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
Enviro-Insight, 2012. Inset Map: Esri Data & Maps

SIZE: A3

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While the vegetation clearance will result in the loss or fragmentation of these sensitive habitat types, it is evident from aerial imagery and field observations that similar habitats are widespread throughout the region. Field surveys indicate that the density and species composition of mammal fauna in adjacent wetland areas (of similar value) are comparable to those within the Project Footprint Area. In addition, as noted in the mammalian baseline, the Project Footprint Area is largely considered as Low–Medium sensitivity for Red Data mammal species. The majority of the Project Footprint Area exhibits only Moderate mammalian sensitivity, and the loss of much of the surface area is not expected to have significant consequences for the mammal population on a local or regional level. However, the loss of sensitive mammalian habitats (largely associated with the fresh-water wetlands), which are essential for corridor movement and as the cornerstone of the trophic system, is expected to have significant impacts on mammals that use these areas. However, the recolonisation of other undisturbed wetland corridors outside of the Project Footprint Area is likely.

The loss of sensitive mammalian habitats will be permanent in duration and of local extent, as the Project activities can be expected to be felt beyond the Afungi Project Site. The abundance of similar habitat types (in the immediate vicinity and surrounding region), combined with the limited amount of sensitive mammalian habitats within the Project Footprint Area, results in an expected Low intensity.

The magnitude of impact is expected to be Low, coupled with a definite likelihood. Therefore, the significance of this impact is MINOR. The degree of confidence in the assessment is High.

Mitigation Measures

These impacts are directly linked to the site clearance activities associated with the construction phase of the Project. While the habitat will remain lost to mammal fauna through the operational phase, no additional habitat loss is expected during the latter phases of the Project. *Figure 12.42* illustrates a post-mitigation Revised Project Footprint Area that minimises the Project's footprint on High sensitivity areas.

- Minimise site clearance activities within areas of High mammalian sensitivities to the extent practicable.

- Establish temporary construction and laydown sites in areas of Low mammalian sensitivities.

- Establish 150m buffer zones around wetlands to prevent adverse impacts. These buffer areas will be clearly demarcated to restrict the movement of construction equipment and workers into adjacent sensitive areas.

Residual Impact

The Revised Project Footprint Area (*Figure 12.42)* reduces the total area of impact on habitats of High mammal sensitivity from 106ha to approximately 99ha. While this reduction may seem of little consequence, it is noteworthy that the Revised Project Footprint Area also reduces the extent of Medium sensitivity areas from about 1,600ha to approximately 500ha, thereby substantially reducing the footprint of impact on mammalian habitats of High and Medium sensitivity. The pre-mitigation significance of MINOR will remain, due to the definite likelihood of the impact. While mitigation is not likely to reduce the significance of this impact, the minimisation of impact on sensitive mammalian habitat is considered prudent.

Table 12.35 Impact of Site Clearance Activities on Sensitive (High and Medium–High) Mammalian Fauna Habitat

	Without Mitigation	**Residual Impact (with Mitigation)**
	Construction Phase	
Duration	Permanent	Permanent
Extent	Local	Local
Intensity	Low	Low
Magnitude	**Low**	**Low**
Likelihood	**Definite**	**Definite**
Significance	**MINOR**	**MINOR**

40°30'0"E 40°32'0"E 40°34'0"E 40°36'0"E

10°46'0"S
10°48'0"S
10°50'0"S
10°52'0"S

Palma
Quitupo
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Maganja
Palma Bay

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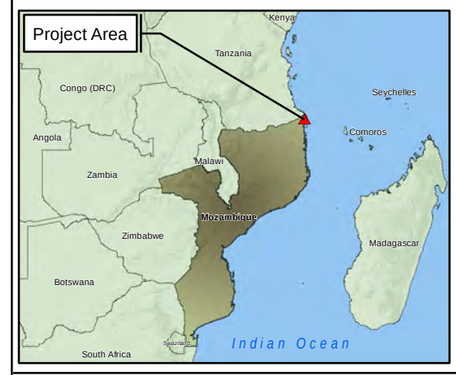
Legend

- Villages / Settlements
- Local Roads
- Nearshore Components
- Revised Project Footprint
- Afungi Project Site

Mammal Sensitivity

- Low
- Medium
- High



MAIN MAP SCALE:

0 1 2 3
Kilometers

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TITLE:

Figure 12.42:
Reduced Impact on Mammals Habitat - Revised Project Layout

CLIENT:

Anadarko
Moçambique Área 1, Lda
eni

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Projection: UTM Zone 37 S, Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
Enviro-Insight, 2012. Inset Map: Esri Data & Maps

SIZE: A3

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12.13.3 Impact of Site Clearance Activities and Road Traffic on Mammal Species by Direct Mortality and Disturbance

Impact Assessment

Mortality and disturbance of mammals is expected to occur during the construction phase of the Project. The operational phase of the Project, while longer in duration, is likely to have lesser impacts, as the vast majority of the resident mammal species are expected to have been displaced during construction activities.

Site clearance activities are expected to present the greatest source of mortality and disturbance-related impacts on the local mammal community. These impacts are expected to result primarily from the construction activities associated with site clearance. The development and use of access roads presents the second greatest threat to the mammal community. These potential impacts are discussed below.

Before construction can begin, the Project Footprint Area must be cleared of cleared of UXOs. This will require the clearance of vegetation to ground level. Mammals tend to be more mobile than other taxa and can escape direct impact. It is likely that the larger mammal species will vacate the Project Footprint Area once these activities commence, thereby avoiding direct mortality. However, the greatest impact is anticipated to be to burrowing mammals, smaller tree-dwelling species and smaller mammals that are unable to escape. Therefore, these mammalian species are at the greatest risk of direct mortality by construction activities.

Mammalian mortality and disturbance related to an increase in vehicle traffic will be largely confined to the access roads connecting the Project to the surrounding area. During the construction phase, a high volume of traffic is expected between the Project Footprint Area and the surrounding area. However, once accommodation facilities are established, it is anticipated that traffic volumes will decrease substantially. It is expected that traffic volumes will be minimal during the operational phase, as the Project will be largely self-sufficient and vehicle movements will be mainly confined within the Afungi Project Site. Therefore, mammal mortality and disturbance can be expected to peak early during the construction phase and gradually taper off over time.

Although mammal species are highly mobile, they are still very vulnerable to collisions from vehicles travelling at speeds higher than 20km/h. Species most vulnerable are the larger species with poor eyesight (such as elephants), ungulates that react negatively to car lights, medium-sized predators associated with human developments (especially jackals, genets and servals) and other small mammals (such as hares, porcupines and aardvarks) that are mostly nocturnal. Very small mammals, such as rats, mice and shrews, are not seen to be a high risk group. The levels of mammalian activity within various areas of the road network will depend in large part on the habitat

types the roads traverse. Habitats that have been identified as sensitive will require special attention to mitigate this impact.

Traffic will have a direct negative impact onsite. The impact will be of short-term duration but of High intensity. This impact will definitely occur and its magnitude is expected to be Medium, resulting in an impact of MAJOR significance.

Mitigation Measures

The following mitigation measures are recommended for the construction phase of the Project:

- As part of induction training, the Project will develop and provide Environmental Awareness Training. This training will include information related to mammalian importance of the area, and will be provided to all staff (as well as visitors and labourers).

- The Project will develop a site management strategy. This strategy will include the following measures to reduce mammalian impact.

    - Clearing of vegetation will be carried out in a systematic fashion from the coastline towards the interior (from north-east to south-west). This will serve to displace mammal populations from the Project Footprint Area towards potentially suitable habitats inland, and decrease the likelihood of injury to individuals.

    - During site clearance, retain a dispersal network of undisturbed vegetation connected to similar habitats outside the Project Footprint Area, to provide corridors for mammals to disperse off-site.

- Construction personnel and equipment will be restricted to the construction area to minimise disturbance to mammal species in adjacent areas.

- Minimise road construction through High sensitivity mammalian habitats.

- Where roads and fences cross High sensitivity mammalian habitats, allow unhindered passage of mammals to the extent practical.

- Enforce vehicle speed limits to reduce the likelihood of mammal deaths or injuries.

In conjunction with the mitigation measures suggested for the construction phase, the following mitigation measures are recommended for the operational phase of the Project:

- Provide training to drivers regarding procedures to follow in the event of a collision. A logbook will be placed in each vehicle to record mammal deaths and injuries.

- Implement speed controls (in areas of High sensitivity mammalian habitats).

- Avoid night driving to the extent possible and, when necessary, implement reduced speeds for night driving.

- Implement a monitoring programme to identify areas of high mammal volumes along particular road alignments, and implement appropriate precautionary behaviour in these areas (eg reduce speed).

Residual Impact

The Revised Project Footprint Area reduces the impact on areas of High mammalian sensitivity, thereby reducing the extent of mammalian displacement by protecting valuable habitats. The application of the construction phase mitigation measures to limit mammalian impacts associated with the site clearance activities are expected to reduce the intensity and likelihood of adverse impacts to Medium and Likely. Therefore, the significance of the residual construction phase impact is expected to be reduced to MINOR.

Similarly, the mitigation measures proposed to reduce mammalian impacts associated with vehicle traffic are expected to reduce the intensity and likelihood of adverse impacts during the operational phase to Low and Unlikely respectively. The resulting post-mitigation impacts are expected to have a MINOR significance.

Table 12.36 Impact of Site Clearance Activities and Road Traffic on Mammal Species by Direct Mortality and Disturbance

	Without Mitigation	**Residual Impact (with Mitigation)**
	Construction Phase	
Duration	Short term	Short term
Extent	Onsite	Onsite
Intensity	High	Medium
Magnitude	**Medium**	**Low**
Likelihood	**Definite**	**Likely**
Significance	**MAJOR**	**MINOR**
	Operational Phase	
Duration	Long term	Long term
Extent	Onsite	Onsite
Intensity	Low to Medium	Low
Magnitude	**Low to Medium**	**Low**
Likelihood	**Likely**	**Unlikely**
Significance	**MINOR to MODERATE**	**MINOR**

12.13.4 Impacts of Habitat Fragmentation and Disruption of Natural Migration Patterns on Mammals

Impact Assessment

Fragmentation is defined as the isolation of tracts of habitat, which limits the natural movements (migrations) of individuals and/or the exchange of genetic material between populations. Fragmentation of habitat is considered a likely outcome of the development of the Project. Fragmentation is anticipated to reach its highest significance at the completion of the construction phase, where it will remain for the duration of the Project.

The development of access roads and linear structures has the potential to create habitat fragmentation and alter natural dispersal routes for mammals. In some cases, areas cleared of vegetation may act as a barrier to migration or dispersal (especially for small or arboreal mammals). Linear features such as fences and trenches have the potential to serve as physical barriers and can create habitat fragmentation through restricted access. Habitat fragmentation occurs most easily through long linear disruptions of the landscape, such as:

- roads;
- fencing;
- trenches; and
- pipelines.

Although not a complete barrier to mammalian movements, roads may present a significant deterrent. Many mammal groups, especially small mammals, are reluctant to cross open spaces, primarily due to the associated risks from predation. In addition, the presence of vehicles may restrict the freedom of movement of animals due to fear of collision, noise and light (at night).

Fencing represents a primary restriction of animal movement between habitats. Variables that influence the effects of fences on mammalian movements include factors such as the height of the fence, the measurements of the linkages, the number of fence lines to be established (double or single) and electrification.

Trenches also present a barrier to almost all terrestrial mammals, due to their inherent linear orientation. Many animals are reluctant to attempt to cross even narrow trenches (especially with vertical side walling) and smaller mammals may become trapped within trenches.

Pipelines can impede the movements of smaller mammals that cannot climb over the structure. Buried pipelines may impede the movement of burrowing mammals. The pipelines will be located within the Project Footprint Area and, as mammalian species will be displaced from this area, no impact is anticipated. However, mitigation measures are provided below as guidance in the event that pipelines are warranted outside the Project Footprint Area.

As stated in *Section 8.10* (mammalian baseline), Afungi Peninsula is not located within a traditional mammalian migration corridor. Therefore, mammalian impacts related to the disruption of migration are expected to be limited. However, habitat fragmentation on a limited scale is likely to result from the development of the Project. The extent of this impact is expected to be local with a long-term to permanent duration, and the intensity is likely to be Medium. A Medium magnitude is expected with a Likely probability of occurrence. resulting in an impact significance of MODERATE.

The degree of confidence in this assessment is High, as the Afungi Peninsula is not a natural mammalian corridor.

Mitigation Measures

The objective of these mitigation measures is to facilitate the movement of mammals between habitats without compromising the Project operations or security. Mitigation measures will strive to increase the permeability of linear features. This depends largely on the engineering design of each structure, and general mitigation measures are provided for each.

- Roads:
    - Access roads established in areas linking sensitive habitats (eg wetlands) will have culverts or underpasses to permit medium-size predators and small ungulates to pass unhindered.
- Fencing:
    - Fences will be established in a systematic fashion from the ocean inland, to avoid entrapment within the fence line.
    - Larger mammals trapped within the fence line will either be removed by a mammal expert/veterinarian trained in animal trapping and/or chemical immobilisation (in the case of large predators, medium-size predators and larger ungulates). Culling is a last resort.
    - Fencing of the Afungi Project Site (but not the Project Footprint Area) will allow for the movement of mammals between sensitive habitats (especially the wetland systems, which serve as corridors for movement), through the use of a secure culvert system or other means of allowing animals to cross. The design of the culvert (or other) system will allow for medium-size predators and small ungulates to pass unhindered.
- Trenches:
    - Excavated trenches will be left open for as short a time as possible to avoid habitat fragmentation.

- Open excavated trenches will have periodic breaks in one slope, with an angle of less than 45°to allow animals to climb out.

- Where practical, the edges of trenches will be raised slightly to create a barrier to prevent animals from running directly into the trench.

- Pipelines (if required outside the Project Footprint Area):

  - Pipelines will either be buried to a depth of 30cm or raised on struts to a height of at least 50cm to allow the free movement of mammals underneath.

  - If the pipeline is to be fenced, periodic overpasses or underpasses will be established to allow for the movement of mammals between habitats.

Residual Impact

The Revised Project Footprint Area reduces the impact on areas of High mammalian sensitivity, thereby reducing the extent of adverse impacts related to habitat fragmentation and/or the disruption of mammalian migration. The application of the above mitigation measures is expected to increase the permeability of linear features and thereby reduce the intensity and magnitude of impacts. With the mitigation measures in place, the significance of the impacts is likely to become MINOR.

Table 12.37 Impacts of Habitat Fragmentation and Disruption of Natural Migration Patterns on Mammals

	Without Mitigation	**Residual Impact (with Mitigation)**
Construction Phase		
Duration	Long term to permanent	Long term to permanent
Extent	Local	Local
Intensity	Medium	Low
Magnitude	**Medium**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MODERATE**	**MINOR**
Operational Phase		
Duration	Long term to permanent	Long term to permanent
Extent	Local	Local
Intensity	Medium	Low
Magnitude	**Medium**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MODERATE**	**MINOR**

12.13.5 Indirect Impacts Related to the In-migration of People on Mammals

Impact Assessment

An influx of people is expected into the Afungi Project Site and surrounds, due to the ease of access to natural resources (road network) and the possibility of obtaining jobs. This is an indirect impact of the Project, which may contribute to several of the impacts already discussed above. While the use of natural resources is currently occurring in the area, albeit at relatively low levels due to low human densities, the potential influx of people can reasonably be expected to increase the intensity of exploitation.

Activities anticipated to have an adverse impact on the surrounding mammalian community associated with an influx of people include:

- Bush fires: these can occur accidentally from cooking fires or cigarette discards, and/or intentionally to clear land for agriculture, and may result in habitat destruction and/or fragmentation. This impact is relatively minor, as the grass sward in the region is not wholly sufficient to create a dangerously combustible environment. However, in the event of an out-of-control fire, slower-moving mammal species such as pangolin may be susceptible.

- Subsistence hunting and poaching: this impact is perhaps currently the biggest threat to wildlife populations in Mozambique. Decades of civil war have given rise to unsustainable utilisation practices throughout much of the country, and have taken a heavy toll on the national mammal population. Often, the level of impact is directly associated with human densities. It stands to reason that the more people move into an area, the greater the impact of subsistence hunting and poaching.

- Use of mammals for traditional medicine and/or killing of mammal species due to superstitious beliefs: many communities covet certain species for use in traditional medicine. An example of this is the pangolin, which is targeted by communities throughout Mozambique. Population influx may also result in an increase in the killing of various species of mammal (such as the lion and spotted hyena) that represent bad luck or ancestral demons.

- Clearing of vegetation: the potential impact may be similar to that described previously. It is assumed that the rate of non-sustainable vegetation use will significantly increase with an increase in the local/regional human population.

- Direct mortality as a result of negative human/wildlife interaction: the Palma District is a relatively high risk area for negative human/wildlife interaction. Historically, the area has seen significant examples of conflict between mammals and humans, including the killing of approximately 30 people by a pair of lions. The increase in human population may see an

increase in human/wildlife interactions. As a result of this, offending mammals (especially elephant, lion, hyena, leopard and hippopotamus) may be destroyed in retaliation (or pre-emptively killed) to reduce the likelihood of adverse interactions with humans (deaths, crop raiding and livestock losses).

- Introduction of alien/invasive mammals: this can occur through accidental or deliberate action. Accidental importation would involve the introduction of alien species through cargo via vehicles and sea vessels. Of particular concern are alien rodents (black rat, *Rattus rattus;* Norway rat, *Rattus norwegicus;* and house mouse, *Mus musculus*) or native rodents that thrive in conjunction with human activity (Southern African multimammate mouse, *Mastomys coucha;* and Natal multimammate mouse, *Mastomys natalensis*). This may bring humans and native animals into direct contact with virulent diseases that are transmitted by these species. Deliberate importation can include the introduction of domestic carnivores such as dogs and cats, which can potentially cause significant changes in the local ecology of the area due to feral hunting activities to supplement their food requirements. There are also concerns with feral/domestic dogs hybridising with the local side-striped jackal population. In addition, domestic livestock such as goats, chickens and cattle are frequently introduced by workers and their families. These animals may contribute to adverse ecological effects such as overgrazing and alien seed dispersal.

The full extent of an influx of people is very difficult to quantify and to mitigate. The staffing requirements for the construction phase present the risk of a large number of people being drawn to the surrounding area. Local workers may bring families, and traders may be drawn to supply goods to the workforce, etc.

While the onset of population influx is likely to occur (and peak) during the construction phase of the Project, the duration is likely to carry through the life of the Project. In some cases, this potential effect of population influx may be permanent, because even after Project closure, a proportion of people may remain in the area. The extent of this impact is expected to be local, with a Medium intensity. The Precautionary Principle is applied in estimating the magnitude of this impact as Medium to High. Population influx will be difficult to mitigate or manage in areas outside the direct control of the Project. An influx of people will likely occur to fulfil the labour requirements of the Project. This impact is assessed to be of MAJOR significance.

During the operational phase of the Project, the workforce will decline to a nominal level. Therefore, it is likely that the intensity of this potential impact would be reduced to Medium, and a Medium magnitude could be expected. However, the potential for adverse impact remains Likely. Therefore, the operational phase impact is assessed to be of MODERATE significance. The degree of confidence for this impact is Moderate, as it assumes a worst-case scenario.

Mitigation Measures

- The Project will undertake a Project Induced In migration Management (PIIM) Study to address environmental and social issues related to anthropogenic encroachment.

- Rodent control:

    - establish appropriate management protocols for food and human refuse;

    - establish quality controls for deliveries to avoid pests in transit;

    - employ early eradication steps at the outset of camp establishment; and

    - rodent poison controls will be strictly monitored to avoid spread to the native small mammal population and/or cause the accidental mortalities of rodent predators such as raptors, owls and other small and medium-size predators.

- Provide mobile fire control unit with trained staff available to extinguish brush fires rapidly to minimise the potential impact on habitats from uncontrolled fires.

Residual Impact

The implementation of the Project Induced In migration Management (PIIM) Study in conjunction with the mitigation measures described above will likely reduce the intensity of impact to Low. While adverse impacts of anthropogenic encroachment remain likely, the magnitude can be expected to be reduced to Medium. The residual significance of impact will be reduced to MODERATE during the construction phase. Similarly, these mitigation measures can be expected to reduce the intensity of impact to Low during the operational phase, resulting in a Medium to Low magnitude. The resulting significance of impact is expected to be MINOR to MODERATE during the operational phase.

Table 12.38 Impacts Related to the In-migration of People on Mammals

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Long term	Long term
Extent	Local	Local
Intensity	High	Low
Magnitude	**High**	**Medium**
Likelihood	**Likely**	**Likely**
Significance	**MAJOR**	**MODERATE**
Operational Phase		
Duration	Long term	Long term
Extent	Local	Local
Intensity	Medium	Low
Magnitude	**Medium**	**Medium to Low**
Likelihood	**Likely**	**Likely**
Significance	**MODERATE**	**MINOR to MODERATE**

12.14 INDIRECT ECOLOGICAL IMPACTS AT PEMBA AND MOCIMBOA DA PRAIA

12.14.1 Impact Assessment Overview

The focus of the Project activities will take place in the Afungi Project Site and Palma District. Hence, this is where the impacts will be predominantly experienced. Indirect impacts at Pemba (being the closest port to Palma) and Mocimboa da Praia (MdP) are nonetheless acknowledged. Onshore, AMA1 and eni currently make use of existing port facilities to support the Project in Palma and are likely to continue to do so eg to import materials and equipment. AMA1 also has a camp at MdP. The Project's use of Pemba Port will decrease once the port facilities at Palma are constructed and operational. There is also the potential for future industrial or other services to establish themselves at Pemba to support the Project. This is an indirect impact that the Project cannot directly control.

Pemba town has experienced growth in recent years, likely as a result of the offshore exploratory seismic and drilling campaigns offshore. Future growth associated with the LNG project may take the form of an expansion to Pemba Port, expansion of Pemba town and MdP town (hotels, houses, etc) and expansion of infrastructure and services (eg roads, water, waste, electricity, etc). Some of this growth may result in impacts to mangroves or beach areas or onshore terrestrial ecology from increased land take required for port or town expansion respectively. Where required, such development will undergo an EIA process where impacts will be identified and appropriate mitigation developed. Indirect ecological impacts at Pemba and MdP are thus screened out of further assessment in this EIA.

Chapter 13

Socio-economic Impact Assessment and Mitigation

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13 SOCIO-ECONOMIC IMPACT ASSESSMENT AND MITIGATION

13.1 INTRODUCTION

This section provides a description of the socio-economic impacts associated with the Project. These impacts have been identified based on research (including the gathering of primary and secondary data), observation and professional judgement.

Impacts assessed in this chapter include:

- Physical and economic displacement (*Section 13.2):*
  - loss of land and physical infrastructure;
  - loss of collective natural resource areas;
  - disruption of land-based economic livelihoods; and
  - disruption of marine-based economic livelihoods.

- Impacts on tourism (*Section 13.3*):
  - disruption of tourism activities; and
  - increased demand for accommodation and leisure establishments.

- Project Induced In-migration (*Section 13.4).*

- Health and safety of the workers and communities (*Section 13.5):*
  - impacts related to communicable diseases; and
  - impacts related to the introduction of roads and road traffic.

- General economic impacts (*Section 13.6*):
  - increased government revenue;
  - employment, training and skills development;
  - procurement of local goods and services;
  - unmet expectations for local employment and procurement; and
  - economic development and economic diversification.

- Impacts to shipping and navigation (*Section 13.7*):
  - international maritime traffic;
  - disruption of commercial fishing activities; and
  - national and regional cabotage.

- Impacts to archaeology and cultural heritage (*Sections 13.8 and 13.9*):
  - onshore archaeology and cultural heritage sites; and
  - offshore archaeology and cultural heritage sites.

13.2 PHYSICAL AND ECONOMIC DISPLACEMENT

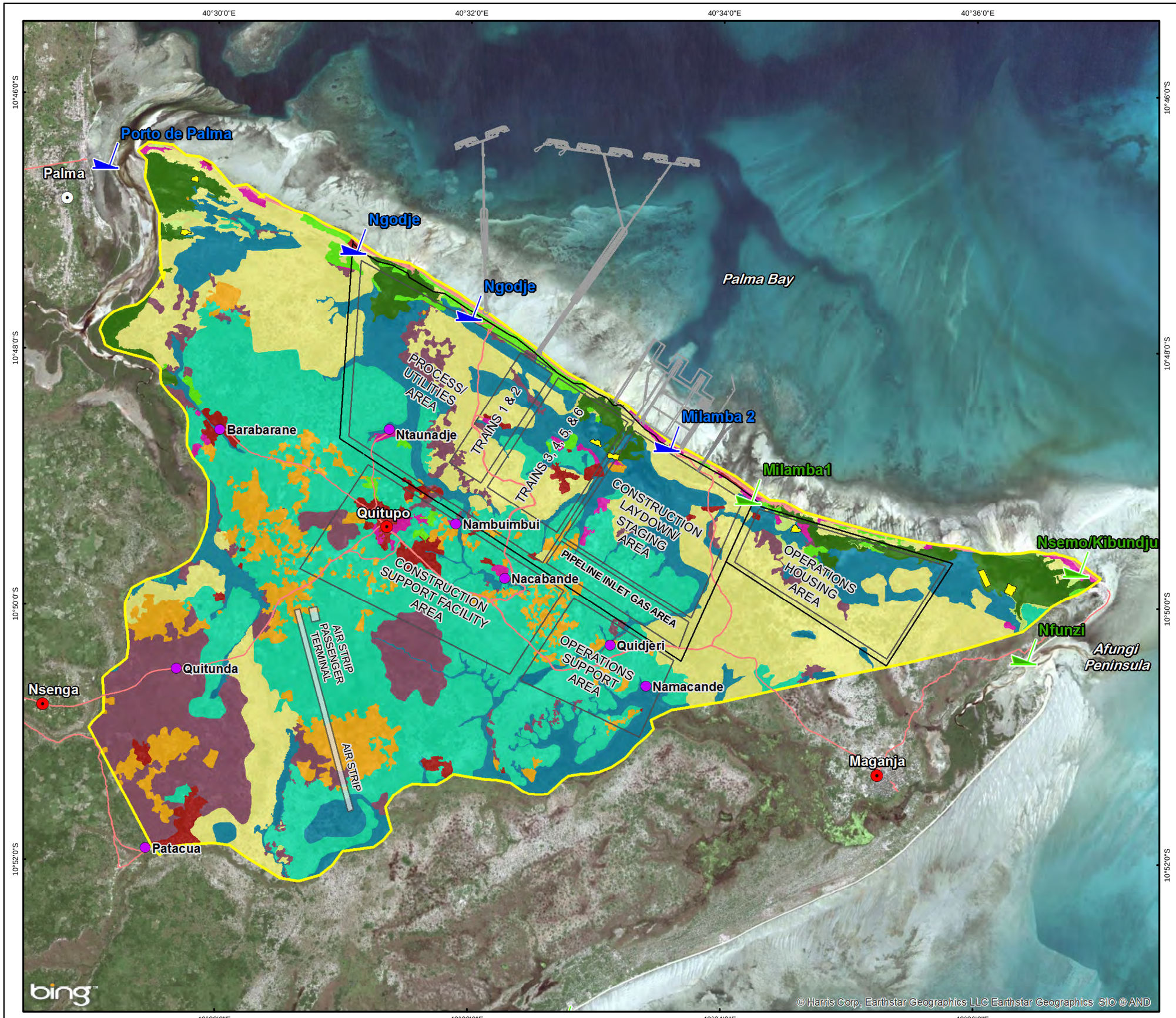
13.2.1 Overview

The Project has obtained a 7,000ha DUAT for development of the LNG Project and Associated Facilities. The need for this area stems from requests from the government for only one LNG site (Item 21 in MICOA's approval of the EPDA Report), as was confirmed by an ENH representative at the public meeting in Maputo on 9 September 2013 (see Public Participation Report, *Annex B*). *Figure 13.1* below illustrates where the layout of the Onshore Project Footprint in the Afungi Project Site Area and Surrounds (including Senga and Maganja) overlaps with existing villages, settlements, fishing zones and Fishing Centres, with existing land-use patterns. Securing the required land will most likely result in permanent physical displacement and both permanent and temporary economic displacement to several villages, as outlined in *Table 13.1* below.

All households in the Afungi Project Site and Surrounds (including Senga and Maganja) are primarily dependent on agricultural and fishing activities for their livelihoods. Permanent physical displacement from within the Onshore Project Footprint will impact land used for subsistence agriculture, and the Offshore exclusion areas will impact directly on subsistence and small-scale fishing activities, trading and transportation routes. Economic displacement occurs from the loss of productive land, dwellings and associated structures, and natural resources critical to the households' subsistence livelihoods, food security and income.

Table 13.1 Summary of Communities Affected by Physical and Economic Displacement

Impact	Affected Receptors	Village/Area
Physical displacement	Human settlements	Quitupo Village and surrounding areas
	Permanent and temporary settlements in and around Fishing Centres	Milamba 1, Milamba 2, N'semo and Ngodje
Natural resources	Forest areas	Forest areas around Ngodje, Milamba 1, Milamba 2, Ntaunadje, Nambuimbui within the Project Site
	Farming areas	Surrounding areas of Quitupo and Ntaunadje, Ngodje, Milamba 1, Milamba 2, Quidjeri, Nambuimbui, Nacabande
Economic displacement	Agricultural land	Quitupo Village and surrounding areas Milamba 1, Milamba 2, N'semo, Ngodje, and inland seasonal farmers
	Fishing Centres/zones	Milamba 1, Milamba 2, N'semo, Ngodje, and inland seasonal fishers



Legend

- District Centre
- Administrative Post Centre
- Villages
- Settlements
- Fishing Centre
- Settlement with Fishing Centre
- Local Roads
- Nearshore Components
- Onshore Project Footprint
- Afungi Project Site

Land Use

- Farming Areas
- Coconut Plantation
- Coconut Plantation with Human Occupation
- Forest
- Coastal Grassland
- Mangrove
- Settlements
- Wooded Grassland
- Mosaic of Floodplain and Farming Areas
- Sandy Beach
- Dune Shrub Vegetation
- Salt Pans

MAIN MAP SCALE:

0 1 2 3
Kilometers

N

TITLE:

Figure 13.1: Current Land Use Pattern in Afungi Project Site

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 52 000

DRAWING: Current LU Pattern Afungi Project Site.mxd

REV: A

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Impacto Projectos e Estudos Ambientais

ERM

Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation. Impacto, 2012. Inset Map: Esri Data & Maps

SIZE: A3

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13.2.2 Loss of Land and Physical Infrastructure

Impact Assessment

The land described in the EIA as the Afungi Project Site is currently occupied by the villagers of Quitupo, surrounding smaller agricultural and production settlements, and Fishing Centres/zones (1). The current population in the Afungi Project Site is 2,733, comprising 733 households. The majority (96 percent) of the Afungi Project Site population are permanent residents, while 4 percent reside in the area seasonally. The Project expects that everyone residing within the Afungi Project Site will be permanently displaced to enable development of the Afungi Project Site for the LNG Facility and associated infrastructure.

Physical displacement requires communities to move to a new location, re-establish livelihoods, and establish dwellings and associated infrastructure potentially within new or existing communities. The impacts of the Project's land acquisition, and the physical displacement of communities within the Afungi Project Site, will occur at a local and regional scale – locally in terms of displacement outside the Afungi Project Site, and regionally through linkages to the supporting livelihood activities (fisheries and agriculture) that households undertake outside the Afungi Project Site and which contribute to local and regional trade; for example, fishing activities and trading surplus agricultural produce. Permanent physical displacement includes the loss of all dwellings and infrastructure associated with the household, livelihood activities and community assets within the Afungi Project Site.

The loss of land and associated physical infrastructure will be permanent, occurring prior to the construction phase and extending throughout the life of the Project. The loss of land is a High intensity and High magnitude impact. The pre-mitigation significance is MAJOR for all phases of the Project.

Mitigation Measures

The Resettlement Action Plan (RAP) is the primary mitigation measure to address permanent physical displacement and temporary economic displacement associated with Project activity. The Project recognises that physical displacement associated with the acquisition of land for Project purposes involves the loss of dwellings, assets and land access, requiring directly affected people to move to another location.

The Project also recognises that economic displacement involves the loss of income streams or means of livelihood and food security resulting from land acquisition. This includes the restriction of access to land or the obstruction of

(1) Fishing zones are areas where some households reside on a permanent basis, engaging in agriculture and fishing, not solely fishing, whereas Fishing Centres are settlements of fishers, where fishers and fish traders live on a permanent or seasonal basis.

access to economic resources, including communal and natural resources (eg marine and aquatic resources, water or forest) resulting from the construction and operations of the Project and Associated Facilities.

The Project, in coordination and cooperation with the Mozambique government, will be responsible for the planning, communication and implementation of all resettlement activities, including physical relocation and the compensation of households directly impacted by the Project, in accordance with Mozambican legislative requirements and the Project's resettlement principles.

The Project's overarching objectives for resettlement are to develop and execute resettlement in a manner that gives physically and economically displaced persons the opportunity to at least restore their livelihoods and standards of living. The Project's Initial Resettlement Plan (IRP) is included in *Annex I*. It describes the approach, principles and procedures that will be followed to manage all unavoidable displacement. The IRP provides the framework for the future development of a full RAP. The RAP will be prepared in accordance with Mozambican legislation and the International Finance Corporation's Performance Standard 5: Land Acquisition and Involuntary Resettlement (IFC PS 5) in close consultation with the affected communities. As noted in Section 3.3 of the IRP, the Project is committed to exploring alternatives which avoid un-necessary resettlement and loss of access and productive land. However, this requires close cooperation and agreement with multiple ministries and departments within the Mozambique government (eg DINAPOT, MICOA, INP, ENH to name a few).

The RAP will be consistent with the goals, objectives, principles and processes described in the IRP and will be designed to address the specific conditions, characteristics and needs of the people and enterprises affected by physical and economic displacement.

The Project's resettlement principles include:

- avoiding and minimising the need for physical and/or economic displacement through alternatives analysis and siting, alignment and other design modifications;

- conducting consultation processes that achieve free, prior and informed participation of affected people and communities (including hosts) in decision-making related to resettlement, and continuing participation during implementation and monitoring/evaluation;

- involving representatives from Provincial and District government, directly impacted Administrative Posts, Localities and communities in the resettlement process;

- compensating affected parties at full replacement value for lost assets in cash or in kind, as per Mozambican practice and in line with Mozambican legislation;

- providing and funding opportunities to improve the living conditions of physically displaced households;

- designing and implementing in a timely manner culturally sensitive and economically sustainable income restoration measures;

- providing measures to support physical relocation and re-establishment;

- identifying and providing special assistance to people who are especially vulnerable to displacement impacts; and

- carefully monitoring and evaluating to ensure that resettlement measures are meeting the needs of affected people and to identify the need for (and implementing) corrective measures.

Residual Impacts

Impact significance will be reduced to MODERATE through participatory planning, communication and implementation of the RAP, guided by the objectives and principles outlined above.

Table 13.2 Loss of Land and Physical Infrastructure

	Without Mitigation	**Residual Impact (with Mitigation)**
	All Phases	
Duration	Permanent	Permanent
Extent	Local to regional	Local to regional
Intensity	High	Medium
Magnitude	**High**	**Medium**
Likelihood	**Definite**	**Definite**
Significance	**MAJOR**	**MODERATE**

13.2.3 Loss of Collective Natural Areas and Land-based Subsistence Livelihoods

The collective natural areas in the Afungi Project Site consist of forests, wooded grassland, floodplains/lowlands, dune shrub vegetation, fruit trees and coconut plantations (1). These resources provide households with materials critical to supporting their livelihoods including construction of their housing, firewood (which is sometimes sold), materials for handcrafts and medicinal plants (see *Table 13.3* below).

(1) The coconut plantations are generally owned by individuals or companies. However, a specific situation was verified in the Afungi Project Site Area and Surrounds (including Senga and Maganja) where a portion of the coconut plantations are still owned by the State, when they were abandoned by their Portuguese owners after independence.

Table 13.3 Natural Resources Available and Used by Communities in the Afungi Project Site

Type of Resources	HH That Use (%)	HH That Consume (%)	HH That Sell (%)
Coconut palm fronds for construction	96.4	87.6	20.9
Coconut palm fronds for handicrafts	87.1	84.7	26.6
Wood poles for home construction	97.8	89.6	12.7
Firewood	94.9	87.8	13.1
Medicinal plants	73.0	89.3	13.7

Key:
HH= Households.

Source: Impacto, 2012.

Access to these natural resources will be permanently lost due to the acquisition of land required for the Project and related activities, including land clearance for the construction of Onshore Project Facilities. Most households residing within the Afungi Project Site have a high level of dependence on communal natural resources and have limited opportunities to find alternative communal assets. The loss of communal land within the Afungi Project Site will have a High magnitude and intensity impact on local residents, due to their dependence on these resources for subsistence livelihoods and income generation. The extent of the impact will be localised, and the duration of the impact will be permanent. The occurrence is definite and the overall impact is assessed as being of MAJOR significance.

In terms of land-based subsistence livelihoods, the households in the Afungi Project Site Area and Surrounds (including Senga and Maganja) are primarily dependent on agricultural activities. The majority of agricultural activities occur away from the settlements in the highland and lowland areas within the Afungi Project Site Area and Surrounds (including Senga and Maganja).

The predominant food crops grown are cassava (produced by 89 percent of households), rice (43 percent), beans (51 percent) and maize (29 percent). The loss of these agricultural areas, sustaining such food crops necessary for food security, will directly impact permanent households within the Afungi Project Site Area and Surrounds (including Senga and Maganja) and seasonal farmers. In addition, some households grow cash crops (eg coconuts and cashew nuts) and fruit trees (see *Table 13.4* below). Cashews and coconuts are an important resource for both permanent and seasonal households, and provide an average annual income of 2,750 and 3,032MZN per household respectively.

Table 13.4 Ownership of Fruit Trees Important to Income Generation

Type of Tree	HH Ownership (%)	Average No. of Fruit Trees per HH
Cashew	63.6	94
Coconut	46.4	59

Type of Tree	HH Ownership (%)	Average No. of Fruit Trees per HH
Mango	45.0	7

Key:
HH= Households.

Source: Impacto, 2012.

The acquisition of the Afungi Project Site for Project purposes will result in disruption to and loss of land-based livelihoods, including subsistence crops, cash crops and fruit trees. The impact on the loss of livelihood activities will be both local and regional, as the loss will directly impact those living within the Afungi Project Site as well as seasonal farmers from inland Palma District.

This is a High intensity impact because households within the Afungi Project Site will permanently lose their cultivated and fallow lands. Households residing outside the Afungi Project Site but using and cultivating land and natural resources within the Afungi Project Site will permanently lose their land and any related infrastructure onsite.

The impact is long term and the magnitude High, as not all directly and indirectly impacted households will be able to continue pre-impact livelihood activities immediately on alternative sites. The occurrence is definite due to the permanent of the Project's land requirements. The impact is assessed to be of MAJOR significance.

On a smaller scale, the subsistence production of salt in small artisanal salt pans located in the Afungi peninsula (see *Section 9.14.8*) might also be affected. However, during fieldwork, it was indicated that these have not been operational for some time. On the Afungi Project Site, 1.5ha of land have been identified as being used for salt production in artisanal salt pans located close to Milamba II and to N´semo (*Figure 9.19*). Salt from these artisanal salt pans is used mostly for consumption and to sell in local markets. Salt is usually used for cooking and to preserve fish by drying and salting it. During fieldwork, it was indicated (via interviews with local people) that the salt pans were not operational for some time and that they hadn't employed many people when they were. Hence, any impact on salt pans are considered to be NEGLIGIBLE.

Mitigation Measures

As described above, the RAP is the primary mitigation measure to address permanent physical displacement and temporary economic displacement associated with Project activities. The RAP details the mitigations and compensation mechanisms that will be implemented in response to impacts associated with the loss of land-based subsistence livelihoods, including:

- recognising permanent and temporary losses and permanent and seasonal farmers by identifying the various livelihood activities and households impacted by Project activities, including loss of forest products (eg legal fruit trees and medicinal plants), households affected by the loss of livelihoods and loss of access to salt pans; and

- compensating impacted parties for temporary loss of agricultural harvests and cropping seasons lost due to construction activities. If compensation arrangements are not concluded prior to the next planting season, impacted parties should be compensated for the near-term crop cycles lost to enable households to achieve food security in the absence of a planned harvest.

As far as possible, permanently displaced households will be settled in areas where there is available land (including land for cashew and coconut plantations), and adequate seedlings will be provided to initiate agricultural activities.

Residual Impacts

Impact significance will be reduced to MODERATE through participatory planning, communication and implementation of the RAP. The implementation of RAP-based mitigation measures will reduce the intensity of the impact to Medium. However, affected people will find it difficult to resume pre-impact access to communal natural resources and land-based livelihoods immediately without support. As such, the residual impact is rated as Medium magnitude and will definitely occur. The significance of the residual impact will be MODERATE. With regards to the impact on salt pans, the impact significance will be NEGLIGIBLE.

Table 13.5 Loss of Collective Natural Areas (Communal Natural Resources)

	Without Mitigation	**Residual Impact (with Mitigation)**
	Construction Phase	
Duration	Permanent	Permanent
Extent	Local	Local
Intensity	High	Medium
Magnitude	**High**	**Medium**
Likelihood	**Definite**	**Definite**
Significance	**MAJOR**	**MODERATE**

Table 13.6 Disruption/Loss of Land-based Subsistence Livelihoods

	Without Mitigation	**Residual Impact (with Mitigation)**
	All Phases	
Duration	Permanent	Permanent
Extent	Local to regional	Local to regional
Intensity	High	Medium
Magnitude	**High**	**Medium**
Likelihood	**Definite**	**Definite**
Significance	**MAJOR**	**MODERATE (NEGLIGIBLE for salt pans)**

13.2.4 *Disruption of Marine-based Economic Livelihoods (Excluding Commercial Fishing)*

Impact Assessment

There are two marine-based livelihood categories undertaken by the population of the Afungi Project Site Area and Surrounds (including Senga and Maganja), namely fishing and sea-based transportation. The Project activities likely to affect the vessels and routes are:

- construction and operation of the Onshore and Near Shore Facilities (including dredging);
- the safety exclusion zones; and
- increased numbers of vessels (construction and operational) operating in Palma Bay.

Table 13.7 describes the size of the proposed safety exclusion zones for the Project, and the two categories of marine-based livelihood activities are explained below.

Table 13.7 Safety Exclusion Zones

Project Phase	Size	Type of Exclusion Zone
Construction	500m radius	Temporary – around construction vessels
	500m radius	Temporary – around construction areas and access corridors
	5,000m radius	Temporary – around offshore drill rigs
Operational	500m radius	Permanent – around all Near Shore Facilities
	1,000m radius	Moving exclusion zones – in front of LNG Carriers in motion
	500m radius	Moving exclusion zones – behind and aside LNG Carriers in motion
	1,000m radius	Temporary – around LNG Carriers during loading

Fishing Activities

Fishing is undertaken by both men and women in the Fishing Centres/zones identified in *Figure 13.1*. In addition, seasonal fishers from other parts of the District fish within Palma Bay and along the coastline of the Afungi Peninsula where Near Shore Project Facilities are proposed.

The impact on fishing activities will be felt by all fishers who use the coastline of the Afungi Project Site Area and Surrounds (including Senga and Maganja), the tidal areas, and the offshore areas facing the Afungi Project Site Area and Surrounds (including Senga and Maganja) and Palma Bay.

Disruption of Passenger and Cargo Sea Transport Vessels

There is a limited road network and few public or private transport services within the Palma District, while communities within the Afungi Project Site Area and Surrounds (including Senga and Maganja) are reliant on walking,

bicycles and sea-based modes of transportation. The existing transport vessels carry passengers and cargo along the coastline of Cabo Delgado Province while Mocímboa da Praia, Olumbe and Palma provide access via road to the rest of the Province and other provinces.

The construction activities of the Onshore, Near Shore and Offshore Facilities will disrupt traditional marine transport routes, as vessels (1) will lose permanent access to landing sites and markets within communities along the coastline of the area around the Afungi Project Site. Transport operators will be required to identify and communicate alternative routes and destinations, and carriers may be required to use longer and possibly more dangerous routes further from the coastline and increase cargo and transport prices to accommodate the additional fuel costs.

If the people living along the coast of the Afungi Project Site are resettled away from the coast, this may also result in the loss of business and therefore income for carrier vessel operators. This would be exacerbated by the additional loss of income sources as a result of reduced access to fishing areas and relocation to environments where current productive skills may be less applicable and/or the competition for resources is greater.

The loss and disruption of fishing activities transport/cargo-based livelihoods along the coastline of the Afungi Project Site will be permanent. The impact on the affected people will occur at the local and regional levels for seasonal fishers and transport/cargo operators. The impact likelihood is definite, and the intensity of the impact will be High. Those affected may not have similar circumstances in which to replicate livelihood activities, and therefore may find it difficult to adapt to change or continue to maintain pre-impact livelihoods. The overall magnitude of this impact will be High during all phases of the Project, for both fishers and transport/cargo operators. As such, the pre-mitigation impact significance will be MAJOR for the fishermen, and the transport/cargo operators and their passengers.

Mitigation Measures

As described in *Sections 13.2.2* and *13.2.3* and above, the RAP is the primary mitigation measure to address permanent physical displacement and temporary economic displacement associated with Project activities. The RAP will detail mitigations and compensation mechanisms implemented in response to impacts associated with the loss of marine-based livelihoods, and will take the following into consideration.

(1) Sea carriers: passenger and cargo boats that are used to transport people and goods along the Afungi Project Site Area and Surrounds (including Senga and Maganja) coastline.

Fishing

- The Project will liaise with the government during the resettlement process to ensure that people living in the Fishing Centres/zones are relocated in/near the coast so as to continue their specific livelihood activities immediately.

- The Project will cooperate with the National Fisheries Administration (ADNAP) toward establishing agreed upon Grievance Procedures (grievances related to fishing activities).

- Where possible, the Project will enable fishing activities to continue in areas of Palma Bay not directly associated with Project activities and outside Project exclusion zones or restricted areas.

- The Project will develop and maintain positive working relationships with the fishing community and community leadership to raise awareness of Project activities directly and indirectly impacting fishing and intertidal gathering activities, and work with communities to develop appropriate mitigations and methods for communications.

- The Project will take into consideration the sociocultural, faith-based and ethnolinguistic sensitivities of the host communities, especially regarding the resettlement of fishing communities, which are composed of migrants from various parts of the region and country (eg Nacala and Nampula provinces).

Cargo/Transport Carriers

- The Project will identify all passenger and cargo vessels operating in the waters adjacent to the Afungi Project Site, in order to:
  - identify alternative routes/points of passage that can be used by the Project vessels or passenger and cargo vessels; and
  - if possible, plan Project activities to allow for the safe passage of carriers at identified times.

- The RAP will include provision for compensation measures associated with any damage and/or loss of cargo directly attributed to vessels engaged in Project activities.

Residual Impacts

Impact significance will be reduced to MODERATE through participatory planning, communication and implementation of the RAP, guided by the objectives and principles in *Sections 13.2.2* to *13.2.3* and additional mitigations described above.

Table 13.8 Disruption of Marine-based Economic Livelihoods (Excluding Commercial Fishing)

	Without Mitigation	Residual Impact (with Mitigation)
All Phases		
Duration	Permanent	Permanent
Extent	Local to regional	Local to regional
Intensity	High	Medium
Magnitude	**High**	**Medium**
Likelihood	**Definite**	**Likely**
Significance	**MAJOR**	**MODERATE**

13.3 IMPACTS ON TOURISM

In 2010, tourism contributed approximately 7 percent of the provincial GDP, and 10 percent of the provincial tax revenue. Almost all the tourism attractions in the Province are located on the 32 islands off the Cabo Delgado coast, although only four islands are located within 30km of the Onshore Project Footprint Area. Project activities that are likely to impact negatively on tourism activities on islands within proximity of the Afungi Project Site include:

- noise, lights, vessel traffic and visual amenity impacts associated with the nature of construction and operation of the LNG Facility;
- environmental impacts associated with vessels involved in the installation of the subsea infrastructure;
- dredging activities that will disturb the quality of the sea water; and
- multiple safety exclusion and restricted zones for marine vessels, potentially encroaching on diving and other tourist activities.

However, positive tourism impacts are also expected, due to increased demand from Project workers and their families (see *Section 13.3.2* below).

13.3.1 Disruption and Loss of Attraction of Tourism Destinations

Impact Assessment

The northern coast of Cabo Delgado has been identified by the Government of Mozambique as a PATI in the Strategic Plan for Tourism Development in Mozambique (2004–2013) as shown in *Figure 13.2*. The existing tourism attractions and facilities that are most likely to be impacted by Near Shore and Offshore Project activities are limited to established tourism ventures on the islands of Queramimbi, Tecomaji and Rongui. Other islands off the Cabo Delgado coast (eg Vamizi) are unlikely to be directly impacted because they are relatively far from the Onshore Project Footprint and the Near Shore and Offshore Project Area activities.

40°10'0"E 40°20'0"E 40°30'0"E 40°40'0"E 40°50'0"E 41°0'0"E 41°10'0"E

10°20'0"S 10°30'0"S 10°40'0"S 10°50'0"S 11°0'0"S 11°10'0"S

TANZANIA

Quionga
Assame
Calomba
Quiwia
Cabo Delgado Peninsula
Issa
Palma Bay
Palma
Tecomaji Island
Manguna
Nkalanga
Macala
Quitupo
Afungi Peninsula
Senga
Nkumbi
Maganja
Aienda
Matapata
Rongui Island
Queramimbi Island
Bawala
Olumbe
Vamizi Island
Metundo Island

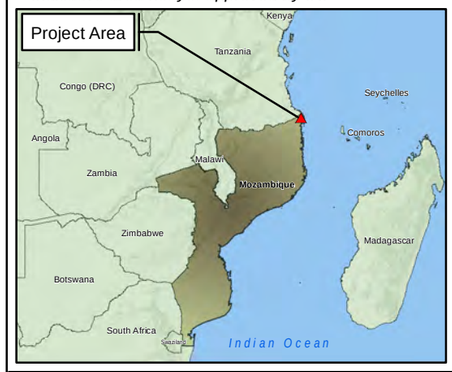
bing

© Harris Corp, Earthstar Geographics LLC State of Michigan

Legend

- Villages / Settlements
- Regional Roads
- Jetty
- Onshore Layout
- Afungi Project Site
- Priority Areas for Tourism Investment 2004 - 2013 Plan

** Indicative area not yet approved by INP*



MAIN MAP SCALE:

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Kilometers

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TITLE:

Figure 13.2: Priority Area for Tourism Investment (PATI) and Tourism Facilities

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: KG	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 400 000

DRAWING: Priority Area for Tourism Investment (PATI) and Tourism Facilities.mxd

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Impacto Projectos e Estudos Ambientais

ERM

Projection: UTM Zone 37 S. Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation AMA1, 2012. Inset Map: Esri Data & Maps

SIZE: A3

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The tourism establishments situated on the islands of Tecomaji, Rongui and Queramimbi will be most affected by the visual and noise impacts resulting from construction activities. This will impact the tranquillity and visual amenity in the area– factors that attract tourists to the island resorts.

The impact of the Project activities (in the construction phase) as it relates to tourism will be localised, but could also extend to the regional level in terms of contribution of tourism to regional and provincial GDP and tax revenue. The impact will be long term due to ongoing Project activities, and the potential for further LNG Facilities being developed in the broader area as a result of offshore exploration by other licence concessionaires. This will result in the impact magnitude being High. The intensity will be High for those relying on tourism for livelihoods (people working in tourism and potential investors),as well as for the Government, which has actively encouraged tourism investment in the Province. The impact likelihood is definite, and overall the impact significance is expected to be MAJOR.

It is envisaged that the impact significance will be reduced during the operational phase of the Project, as there will be a reduction in visual intrusion due to less infrastructure (eg rigs) and vessels engaged in Project construction activities. Even though the numbers of construction and support vessels may decrease during the operational phase, the number of LNG Carriers accessing the LNG Export Terminal Facilities will increase over time as additional LNG Trains are constructed, and maintenance dredging is undertaken when required. During operations, while the visual amenity impact is considered minor, the LNG Facility will be visible from Tecomaji and Rongui islands. The intensity of the operational phase impact is expected to be High and long term. Impact significance is expected to be MAJOR.

Mitigation Measures

- Where possible, the Project will design its facilities such that there is less visual intrusion on the tourism receptors.

- The Project will engage directly with tourism operators from Queramimbi, Tecomaji, Rongui and Vamizi islands regarding the potential disruption and loss of attraction resulting from Project construction and operations. The Project will communicate and maintain ongoing engagement with tourism operators regarding Project activities such as the parameters of safety exclusion zones, and implementation of a Grievance Mechanism for raising Project-related concerns. The Grievance Mechanism will outline procedures for the resolution of grievances such as holding discussions with the tourism operators to determine possible solutions, and an assessment of the tourism operator's satisfaction with the resolution or grievance closure.

Residual Impacts

Even with the implementation of the above mitigation, the residual impact will remain MODERATE for construction and operational activities.

Table 13.9 Disruption and/or Loss of Attraction of Tourism Destinations

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Short to long term	Short to long term
Extent	Local/regional	Local/regional
Intensity	High	Medium
Magnitude	**High**	**Medium**
Likelihood	**Definite**	**Definite**
Significance	**MAJOR**	**MODERATE**
Operational Phase		
Duration	Long term to permanent	Long term to permanent
Extent	Local/regional	Local/regional
Intensity	Medium	Low
Magnitude	**High**	**Medium**
Likelihood	**Definite**	**Definite**
Significance	**MAJOR**	**MODERATE**

13.3.2 Increased Demand for Tourism Facilities (Accommodation and Leisure)

Impact Assessment

The Government of Mozambique has identified the northern coast of Cabo Delgado as a PATI in the Strategic Plan for Tourism Development in Mozambique (2004–2013). The presence of the Project is likely to create a positive impact in terms of increasing demand for accommodation in the Palma District, due to a potential increase in business travel to northern Cabo Delgado in search of business opportunities. Visitors to the Palma District will require accommodation and may extend their stay for leisure purposes, creating opportunities for the development of tourism, hospitality and recreational amenities. This is likely to occur during the Project inception stages and throughout the construction and operational phases. Some expatriate workers may encourage their families to visit, thereby increasing the demand for accommodation, recreation and tourism activities within and around the Palma District and northern Cabo Delgado.

The impact of increased demand for leisure accommodation will likely peak during the Project's construction phase, but may experience increase should other LNG Facilities be developed, and as business and economic development occur in the region. During the construction phase, the impact will be experienced at a local level over the medium term. The intensity and magnitude of impact could range from Low to Medium, with a Likely probability of occurrence. Thus, a MODERATE POSITIVE impact is expected during the construction phase.

During the operational phase, the impact is likely to be local and long term. The intensity of the impact would likely start at Low and increase to Medium should future tourism developments begin to cater for industry and business-related tourism. Thus, a MODERATE POSITIVE impact is expected during the operational phase.

Enhancement Measures

Economic development and enhancement of the tourism sector are the mandate of Government. As a good neighbour, the Project's enhancement measures may include facilitating engagement between key Government and private sector stakeholders regarding tourism, recreation and economic development opportunities for the region. These measures should be considered alongside those proposed in *Sections 13.6.1* to *13.6.5*. From a regional development perspective, the Project will support tourism initiatives by encouraging Government investment of Project revenue into Cabo Delgado Province, and specifically Palma District, to support Government's tourism and economic development policies and objectives. The Project will also raise awareness internally among Project staff on the available tourism facilities and excursions (including diving and fishing) in the area.

Residual Impacts

The residual impact will remain as MODERATE POSITIVE.

Table 13.10 Impact of Increased Demand for Tourism Facilities (Accommodation and Leisure)

	Without Mitigation	**Residual Impact (Enhancement Measures)**
Construction Phase		
Duration	Long term	Long term
Extent	Regional	Regional
Intensity	Low	Low
Magnitude	**Low**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MODERATE POSITIVE**	**MODERATE POSITIVE**
Operational Phase		
Duration	Long term	Long term
Extent	Regional	Regional
Intensity	Low	Low
Magnitude	**Low**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MODERATE POSITIVE**	**MODERATE POSITIVE**

13.4 IMPACTS RELATED TO PROJECT INDUCED IN-MIGRATION

This section describes the characteristics and potential positive and negative impacts of Project Induced In-migration (PIIM), and describes how the Project will consider PIIM as a Project impact, namely to:

- assess the risks and impacts of PIIM on the ADI and AII; and

- develop PIIM-specific mitigations for incorporation into the relevant ESMPs.

In-migration is naturally occurring and can involve the domestic and cross-border movement of in-migrants motivated to enhance their quality of life, for example through improved access to education and healthcare services and infrastructure, greater employment opportunities, improved food security, proximity to family and faith-based or political communities, and more favourable trade and business opportunities.

A subset of in-migration is PIIM, involving '*the movement of people into an area in anticipation of, or in response to, economic opportunities associated with the development and/or operation of a new project*' (IFC, 2009). A Project's host communities often refer to in-migrants as 'outsiders' as they may not have any prior affiliation with communities; for example, in the context of the Project, prior affiliation with communities within the AII, ADI, Palma District or specifically the Afungi Project Site Area and Surrounds (including Senga and Maganja) and potential resettlement host communities.

In-migrant groups can include:

- labourers and their families;

- entrepreneurs/traders;

- opportunists looking to qualify for Project-related benefits, such as:
  - local employment (and the number of people supported by that employee's wage – known as the multiplier effect),

  - training opportunities, and

  - resettlement entitlements;

- informal money lenders;

- commercial sex workers; and

- camp followers.

Project motivated in-migrants may not only be outsiders – they may also be resettlers and their relatives moving within the Project area (eg within the AII and the Palma District) in order to position themselves to secure potential project benefits such as:

- resettlement and livelihood compensation entitlements;

- Project investments, such as improved healthcare facilities or community infrastructure;

- Project-initiated training and employment opportunities; and

- living with or nearby legitimate directly impacted community members to leverage Project benefits and entitlements.

13.4.1 PIIM in the Project Context

In-migration is a natural element of the Project's socio-economic, cultural and ethnolinguistic operating context, made up of interdependent components and influences including:

- historical trading back and forth along the East African coast, supporting temporary and permanent migration, using Swahili as a common southern East African coast lingua franca;

- entrenched trade and transport-related in-migration, with specific transport landing in Palma Bay and along the Afungi Project Site Area and Surrounds (including Senga and Maganja) coastline, and trading sites in Palma Town and the Afungi Project Site Area and Surrounds (including Senga and Maganja);

- historical coastal fishing grounds within the Palma District and along the Afungi Peninsula supporting informal employment, and small-scale trading opportunities among local communities and visiting regional and international fishers and traders;

- a vulnerable community in the Afungi Project Site Area and Surrounds (including Senga and Maganja), characterised by:
  - reliance on subsistence livelihoods,
  - low levels of educational attainment,
  - limited experience with a cash economy,
  - little or no formal employment/training opportunities and experience,
  - a rural lifestyle with limited exposure to sophisticated entrepreneurial behaviours,
  - limited awareness of land ownership and occupation rights, and
  - entrenched traditional leadership and cultural norms and practices;

- a border post in close proximity to the Tanzanian border, creating the first trading opportunity with local communities to secure local supplies or

trade imports. Conversely, the last opportunity for the procurement of good and services for traders and travellers moving north; and

- potential PIIM as awareness of Project activities increases through local, regional and provincial formal and informal information exchange and disclosure of Project activities.

13.4.2 Responsibilities for Addressing PIIM

The Project has requested 7,000ha for development of the LNG Project and Associated Facilities. As described in *Section 13.2.1,* acquisition of this site will involve the physical and economic displacement of all communities and livelihood assets from within the Afungi Project Site.

As such, PIIM will not occur within the Afungi Project Site or within the Onshore, Near Shore and Offshore Project Facilities and associated exclusion zones. PIIM impacts may instead occur outside the 7,000ha area requested by the Project, in communities within the ADI including the Palma District, communities within close proximity to the Afungi Project Site Area and Surrounds (including Senga and Maganja), potential resettlement host communities and those in nearby Administrative Posts and Localities within the Palma District.

The way in which the Project plans, communicates and delivers the LNG Plant and Associated Facilities can contribute to discouraging PIIMs from travelling to or settling near the Afungi Project Site or within nearby or directly impacted communities. As such, the Project will develop mitigation measures to address PIIM as a direct and indirect Project impact.

However, the Project will need the provincial and District government to deliver on mandated roles and responsibilities associated with spatial land-use planning, infrastructure development and maintenance, governance and robust fiscal management to create a platform from which the Project can implement successful mitigations and potentially collaborate with government to achieve positive impacts from PIIM.

While the Project is responsible for its implementation and delivery strategy (including environmental and social impacts both inside and outside the Onshore Project Footprint), there are other stakeholders with important roles in the management and implementation of PIIM mitigations. Outside the 7,000ha area requested by the Project, responsibility for environmental and social issues, land use and development, infrastructure development and maintenance is prescribed in Regional Plans, which in turn provide direction for District Plans, the responsibilities for which sit with provincial government and District Administrators respectively. As such, provincial and local government are important stakeholders in recognising the potential for, and developing management and mitigation measures to, discourage PIIM, and are primary stakeholders in PIIM management.

13.4.3 Impact Assessment – Positive PIIM Impacts

Positive impacts of PIIM can be difficult to achieve and are highly dependent on the proactive commitment of the host country's government. When planned in agreement with Project partners including the Project operator, central, provincial and local government, host communities, and with the support of the NGO and donor community, the positive impacts of PIIM on a Project's host communities may include:

- improved access to and opportunities for local employment;
- diversity of lifestyles and social experiences;
- changing attitudes towards vulnerable groups; and
- alternate livelihood opportunities.

Positive local and regional business development impacts for host communities associated with PIIM can include:

- development of supply chain links to mainstream economies;
- increased local skills base and local labour pool (when business development opportunities prioritise directly impacted communities);
- new markets for local products and services;
- increased diversity and availability of goods and services;
- improved local training and skills development opportunities;
- monetisation of remote rural economies, improving purchasing power and increasing trade; and
- potential improvement in opportunities for informal sector businesses (IFC, 2009).

Enhancement Measures

Creating positive PIIM impacts requires a participatory approach to planning and execution of community benefit initiatives and Project risk and impact mitigations, involving (but not limited to) provincial and district level government, civil society organisations, the NGO and donor community, public-private sector partnerships and direct and indirectly impacted communities within the Project's ADI. Enhancement measures may include:

- the Project working alongside Government and the NGO and donor community throughout the life of the Project to encourage revenue distribution to Cabo Delgado Province and Palma District, in support of regional and provincial government capacity building, governance and civil society empowerment.

- the Project facilitating representative local and regional development forums to identify potential economic and social development initiatives and potential implementing partners, driven by provincial and District-level development plans and objectives.

- the implementation of a Project National Content Strategy in alignment with central, provincial and District-level economic and social development objectives.

13.4.4 Impact Assessment – Negative PIIM Impacts

Those most negatively impacted by PIIM are the Project's host communities, including those within the Palma District, communities within close proximity to the Afungi Project Site Area and Surrounds (including Senga and Maganja), potential resettlement host communities and those in nearby Administrative Posts and Localities within the District.

In-migrants' presence and their activities can directly and indirectly impact the Project's host communities and can include the environmental, social and economic impacts associated with in-migration, which can lead to deterioration in the social context in which the Project's host communities reside.

If unmitigated and approached without the direct involvement and active engagement of provincial and District-level government, in-migrants may contribute an overall decline in the well-being and welfare of the resident population by threatening their way of life and the basis of existing livelihoods, and placing additional pressure on public infrastructure, services and utilities (IFC, 2009).

Examples of negative PIIM impacts on the Project's host community can include:

- the breakdown of traditional household and community institutions, traditional leadership structures and cultural norms leading to a loss of community identity and resilience;

- food scarcity through diminished communal and natural livelihood assets;

- competition for natural resources, land occupation and use, actual and perceived project benefits and entitlements;

- increased vulnerabilities associated with poverty, loss of livelihood assets and associated community status/perceived wealth and indebtedness, and domestic violence;

- increased pressure on existing infrastructure, such as inadequate schools, health centres and waste disposal facilities, and the limited formal water supply network.

- unplanned, unmanaged and spontaneous land occupation and construction of dwellings on private or government alienated land, placing stress on surrounding national resources and nearby communities;

- increased opportunities for the transmission of communicable diseases from in-migrant populations to local communities, with potential for epidemics;

- increased disposable income may result in increased incidences of prostitution and casual sexual relations. These sexual relations could lead to an increase in STIs and an increased incidence of HIV/AIDS;

- in many cases, job-seeking in-migrants are male, who move into an area without their wives or partners. Some of the migrants start relationships with local women, which may lead to children being conceived with migrant workers, potentially out of wedlock. Given the temporary nature of the work, it is possible that both the women and children will be abandoned when the construction phase ends and the migrants move on, leaving single, vulnerable, female heads of households;

- rising crime, violence and tensions within and between host community and in-migrant populations, resulting in a breakdown of law and order (IFC, 2009);

- increased occurrence/practice of social vices as a result of increased disposable income, or in reaction to undue stresses and tensions associated with a breakdown in household dysfunction and social cohesion;

- increased consumption of alcohol (and drug use, should this occur) leading to an increase in the number of people indirectly affected by, or vulnerable to, alcohol and drug abuse; and

- a lack of knowledge of the local culture, beliefs, habits and rules of behaviour by outsiders may, intentionally or unintentionally, cause conflicts with members of the community. Examples are faith-based expectations regarding relationships with women and children, and traditional protocols for community engagement, raising grievances or engaging in community business (such as requesting allocation of land).

Mitigation Measures

Given the broad motivations and opportunities for in-migrants, preparation for the management and mitigation of PIIM needs to be equally broad. PIIM is a cross-cutting issue related to most social and environmental impacts associated with the Project's planning and construction phase strategies.

PIIM risks that the Project can manage actively relate to the Project execution strategy, behaviour of Contractors, management of environmental and social

impacts, careful planning and delivery of local employment, training and procurement opportunities, and selective community investment initiatives, as extrapolated below. The Project will undertake a PIIM Study and develop specific mitigations to reduce the likelihood, magnitude and intensity of PIIM-related negative impacts. These will be incorporated into the relevant Project and Contractor ESMPs and Project Design, and include but are not limited to:

Local Government Roles and Responsibilities

- Engage with relevant government departments and authorities to understand their mandated roles and responsibilities for land ownership, land occupation (including allocation) and land-use planning, specifically in the Palma District.

- Share with provincial and District-level government the mitigations that the Project can contribute to reducing the potential for PIIM, recognising the Project's specific responsibilities (ie no direct responsibility for land-use planning, infrastructure and maintenance outside the Afungi Project Site).

- Facilitate engagement with relevant government representatives at provincial, regional and District level and the NGO and donor community to help develop spatial land-use plans, land zoning and a Palma District master plan to assist government to plan effectively for:
  - future land use;
  - planning and infrastructure development and maintenance needs;
  - good governance and accountability in fiscal management;
  - revenue distribution from central and provincial government to deliver economic and social development benefits;
  - government and civil society organisation capacity building; and
  - capacity building within the law and order and border control sector and associated infrastructure.

Stakeholder Engagement and Sociocultural Awareness

- Develop relationships with and maintain ongoing engagement with directly impacted communities, aligned with the Stakeholder Engagement Plan (SEP), in a forum consistent with their cultural and traditional norms and practices.

- Develop representative community groups to discuss PIIM actively, and build capacity to identify culturally appropriate and traditional methods

for discouraging the arrival of outsiders into a community, including methods for land allocation and rights to engage in livelihood activities.

- Support community capacity building among traditional leadership to diffuse or resolve tensions within and between local and in-migrant communities using community police, traditional courts and dispute resolution mechanisms.

- Engage with local government to understand public and private sector roles and responsibilities associated with the management of direct and indirect impacts associated with PIIM.

- Work with village leadership and civil society organisations to develop capacity and support for vulnerable groups.

Resettlement

- Effective implementation of the RAP, including communication of resettlement eligibility criteria, cut-off dates for resettlement entitlements and disclosure of compensation criteria to discourage opportunist in-migration into areas identified for physical displacement.

- Through effective RAP implementation, identify risks to food scarcity and potential increased competition for livelihood assets between resettlement communities, host communities and potential in-migrant settlements.

- Engage with local government to encourage areas of unoccupied land and other buffers to surround Project resettled and host communities and minimise nearby uncontrolled and spontaneous land occupation.

Project Design and Facilities Access

- Operate a closed camp for the expatriate, third country national (TCN) and national workforce on rotational work schedules, with all accommodated contractors prohibited from direct engagement with local communities.

- Adopt a fly-in, fly-out transportation policy for rotational staff to limit communities' direct interaction with the Project workforce.

- Where possible, limit work vehicles and machinery to designated access and work site areas, and discourage the land-based transportation of Project equipment to limit vehicle traffic to the Afungi Project Site, thereby reducing the motivation for in-migrants to follow Project vehicles towards the Project Camp and work sites.

- Limit the movement of employees and contractors to within Project-defined areas, using designated transport (ie no walking outside the

Onshore Project Footprint) and transportation routes (ie designated Project roads).

Employment and Contractor Management

- Develop a recruitment strategy to focus local employment opportunities on directly impacted Project communities.

- Develop local workforce development strategies and provide guidance to contractors to prioritise local recruitment within the Palma District.

- Strictly prohibit the hiring of casual labour at the camp and work site entrances, through local recruitment agents, or by going directly to communities and/or local government.

- Implement the local labour recruitment procedure provided by the Project in a transparent manner and non-discriminatory fashion, providing equal opportunities regardless of political opinion, gender or religious affiliation.

- For the national rotational workforce, undertake recruitment and employment procedures, and provide transportation to and from the Project Camp from the point of recruitment.

- The Project will share information on employment and procurement processes to manage the expectations of local job seekers. These policies should be communicated at national (in conjunction with other Project announcements), provincial and local level.

- Establish online registration for employment opportunities for the skilled and semi-skilled workforce.

Local Procurement and Supply

- Communicate to contractors and local government and publicly disclose that Project goods and services will not be purchased informally at Project Camp sites or work locations, and that goods and services will only be procured through formal contracts via approved suppliers.

Community Health

- Strengthening of healthcare service capacity.

- Effective resettlement planning and implementation to include effective water and sanitation programmes.

- Implementing health, hygiene and sanitation, communicable disease, STI and HIV/AIDS education campaigns to raise awareness among

communities of the potential health impacts associated with increasing population, and pressure on water and waste disposal services.

- Raising awareness regarding alcohol abuse, drug dependency associated with a breakdown in household structures, community tensions and social dysfunction associated with the potential negative impacts of PIIM.

13.4.5 Residual Impacts

The impacts associated with PIIM are likely to develop during the construction phase when investment in employment and training, ongoing support for resettled and host communities, and potential benefits from impact mitigations are being provided, and community development initiatives are at their peak. However, during operations when fewer employment opportunities are available, some in-migrants forming the communities established during the construction phase may move on in anticipation of employment elsewhere, while others may remain as permanent residents and camp followers able to sustain a living from indirect Project employment, or potential employment from other LNG projects in the region.

As such, PIIM impacts can extend beyond the life of the Project, and become permanent. The effects of the increased population will be high, as people will continue to compete for land and other resources, creating ongoing tensions within and between in-migrants and local community members, leading to a breakdown in social cohesion and increased law and order issues.

Therefore, the impact magnitude and intensity will be High and permanent, the likelihood of occurrence definite, and the extent of the impact local and extending to regional. Overall, the impact is therefore of MAJOR significance.

Following implementation of the above mitigation measures by the Project, and depending on the acceptance of provincial and District-level government roles and responsibilities, this impact may be reduced from MAJOR to MODERATE significance. PIIM is difficult for the Project to manage alone, as it is heavily reliant on the capacity, fiscal management and good governance of provincial and District-level government's mandated responsibility to manage and implement key mitigations.

Table 13.11 Impacts Related to Project Induced In-migration

	Without Mitigation	**Residual Impact (with Mitigation)**
	All Phases	
Duration	Permanent	Permanent
Extent	Local and regional	Local and regional
Intensity	High	High
Magnitude	**High**	**Medium**
Likelihood	**Definite**	**Definite**
Significance	**MAJOR**	**MODERATE**

13.5 COMMUNITY HEALTH IMPACTS

This section is structured in terms of the environmental health areas (EHAs) used to provide the Socio-economic Baseline description in *Chapter 9*. The population potentially affected by the Project from a health perspective are considered by similar exposure groups, known as potentially affected communities (PACs), as shown in *Figure 13.3*. This section will address potential community health impacts for the following relevant EHAs:

- EHA 1: Communicable Diseases Linked to Overcrowding and Poor Environmental/Socio-economic Conditions;
- EHA 2: Vector-related Diseases;
- EHA 3: Soil, Water and Waste-related Diseases;
- EHA 4: Sexually Transmitted Infections and High-risk Sexual Practices, including HIV/AIDS;
- EHA 5: Food and Nutrition-related Issues;
- EHA 7: Accidents/Injuries;
- EHA 10: Social Determinants of Health;
- EHA 12: Healthcare Services and Infrastructure; and
- EHA 13: Health Programmes and Systems.

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10°30'0"S 10°35'0"S 10°40'0"S 10°45'0"S 10°50'0"S 10°55'0"S 11°0'0"S 11°5'0"S 11°10'0"S 11°15'0"S

TANZANIA

Quionga

R1260

Quionga

PAC6

NC

PAC4

Cabo Delgado Peninsula

Palma Bay

R775

Palma

PAC1

Palma

PAC3

Tecomaji Island

R763

PAC2

Afungi Peninsula

Senga

Maganja

PAC8

Pundanhar

Rongui Island

Queramimbi Island

R762

PAC6

PAC5

Mute

Olumbi

Pundanhar

NC

PAC7

R764

Vamizi Island

Olumbe

Nangade

Metundo Island

Mocimboa da Praia

40°0'0"E 40°5'0"E 40°10'0"E 40°15'0"E 40°20'0"E 40°25'0"E 40°30'0"E 40°35'0"E 40°40'0"E 40°45'0"E 40°50'0"E

Legend

- Villages
- District Centre
- Locality Centre
- Administrative Post Centre

Roads

- Tertiary
- Local
- Non Classified

- Afungi Project Site

Province

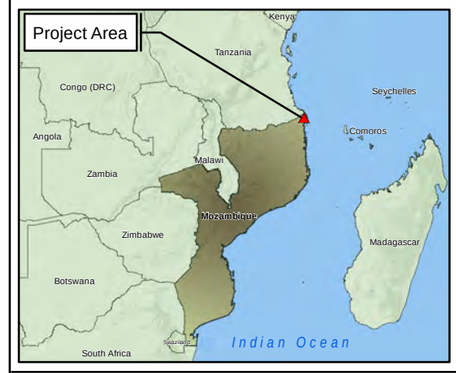
- Cabo Delgado

- District Boundary
- Palma District

- Administrative Post Boundary

Main Marine Access Routes

- Route for Tourism Operators
- Transportation of passenger and goods



MAIN MAP SCALE:

0 5 10 15 20

Kilometers

N

TITLE:

Figure 13.3:
Potentially Affected Communities (PAC) in Palma District

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 330 000

DRAWING: Potentially Affected Communities in Palma District.mxd

REV: A

ERM
Great Westerford Building
240 Main Road
Rondebosch, 7725
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Tel: +27 21 681 5400
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Impacto Projectos e Estudos Ambientais

ERM

Projection: UTM Zone 37 S Datum: WGS84
Source: DIVA-GIS. Impacto, 2012.
Inset Map: Esri Data & Maps

SIZE: A3

T:\GIs Projects\0133576_Anadarko_Moz_LNG\Mapping\MXD\ESIA\Chapter13\Potentially Affected Communities in Palma District.mxd

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13.5.1 Communicable Diseases Linked to Overcrowding and Poor Environmental/ Socio-economic Conditions

Impact Assessment

The following factors have the potential to influence the transmission of communicable diseases related to housing, overcrowding and poor socio-economic conditions, with a resultant health impact.

- The Project is likely to be an attractor, with resulting in-migration likely to influence environmental health conditions and potentially play a role in increased disease transmission, as well as introducing diseases to which local communities have had little/no exposure.

- The origin of any incoming TCN workforce needs to be understood so that communicable diseases are not introduced to the area.

- TB may also present a risk among workers who originate from areas where TB is more prevalent, as this can increase local transmission.

- Adequate accommodation planning will need to be provided for the Project workforce, to prevent overcrowding and the potential for disease transmission in large groups of people.

Without mitigation, the intensity would be High and the extent local. The impacts would be of a long duration. It is likely that the impact may occur if not effectively mitigated and, coupled with the High magnitude, a MAJOR significance is expected. The impact can occur from construction into the closure phase, and chronic diseases such as TB may cause long-term health impacts.

Mitigation Measures

Proposed Project impact mitigations include, but are not limited to:

- operating a closed camp policy for expatriates, TCNs and the rotational national workforce to limit exposure of impacted communities to the Project workforce, and therefore to potential communicable diseases and potential transmission;

- implementing health service planning and strengthening to ensure adequate health service capacity for TB diagnosis and management in the Study Area; and

- designing and developing appropriate environmental health programmes to reduce the potential risk of airborne pollutants such as dust, which may impact on community health.

Proposed occupational health and safety mitigations will be outlined in an Occupational Health and Safety Management Plan, and include:

- developing a Project-based TB management policy and programme for the workforce. This would include screening employees for TB at the point of recruitment, providing adequate referrals and supporting ongoing treatment programmes from the workplace medical service to national treatment programmes;

- developing a vaccination programme for all employees, contractors and visitors against relevant vaccine-preventable diseases based on risk;

- contractor management and compliance with the TB and vaccination programmes will be developed and managed by the Project; and

- ensuring that adequate housing is available to the workforce so that overcrowding does not occur.

Residual Impacts

With effective and sustained mitigation, the intensity would be adjusted to Medium, with the local extent remaining. The impacts would be adjusted to shorter-term duration with a reduced likelihood to Unlikely. Thus, the residual impact would be MINOR.

Table 13.12 Impacts on Overcrowding and Related Communicable Diseases

	Without Mitigation	**Residual Impact (with Mitigation)**
	Construction Phase	
Duration	Long term	Short term
Scale	Local	Local
Intensity	High	Medium
Magnitude	High	Medium
Likelihood	Likely	Unlikely
Significance	**MAJOR**	**MINOR**
	Operational Phase	
Duration	Long term	Short term
Scale	Local	Local
Intensity	High	Medium
Magnitude	High	Medium
Likelihood	Likely	Unlikely
Significance	**MAJOR**	**MINOR**

13.5.2 Vector-related Diseases

Impact Assessment

The Project has the potential to influence the transmission of vector-related diseases in the Study Area in the following ways:

- During construction, the modification of the environment may result in an increased number of suitable breeding sites. Under new favourable environmental conditions, populations of the mosquito vectors could increase very quickly and increase the risk for disease transmission.

- The potential for PIIM into the area may also play an indirect role in increasing the malaria burden in the communities.

- The physical relocation must be managed, so as not to impact negatively on communities or host sites. The location of the resettlement sites and appropriate housing and town planning are important to consider with any relocation, so as not to increase the risks related to vector-borne disease transmission.

- The shipping of products and equipment from international destinations to support the Project has the theoretical potential to introduce arboviruses, such as dengue and chikungunya fever, into the Study Area. The area is reported to house the vector for human African trypanosomiasis. The disease is not reported in the area, but with increased wealth and a potential for increased animal husbandry with cattle, there is a risk of the disease being introduced.

Without mitigation, the intensity would be High and the extent would be local. The impacts would be felt more during construction, and would persist into the long term but at a lower magnitude. The impact likelihood is definite if not effectively mitigated and, coupled with the High magnitude, a MAJOR significance is expected. The impact can occur from construction into the closure phase.

Mitigation Measures

Proposed Project impact mitigations include, but are not limited to:

- developing a robust baseline to describe the malaria burden; and

- considering health systems strengthening (HSS) in the Palma District to extend the NMCP policies and activities into the Study Area and District to mitigate the effects of increased local disease patterns and PIIM mitigations.

Proposed occupational health and safety mitigations will be outlined in an Occupational Health and Safety Management Plan, and will include:

- developing an integrated malaria and vector control management plan that includes:
  - chemical control programmes, which should be based on integrated vector/pest management principles;

- effective case management of suspected and confirmed cases; and

- appropriate information, education and communication (IEC) programmes within the workforce mobilisation plan that occur prior to secondment and are ongoing at site.

Residual Impacts

With effective and sustained mitigation, the intensity will reduce to Medium, a Likely occurrence and with a Medium magnitude. The residual impact would be MODERATE.

Table 13.13 Impacts on Vector-related Diseases

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Short term	Short term
Scale	Local	Local
Intensity	High	Medium
Magnitude	High	Medium
Likelihood	Likely	Likely
Significance	**MAJOR**	**MODERATE**
Operational Phase		
Duration	Long term	Long term
Scale	Local	Local
Intensity	High	Medium
Magnitude	High	Medium
Likelihood	Likely	Likely
Significance	**MAJOR**	**MODERATE**

13.5.3 Soil, Water and Waste-related Diseases

Impact Assessment

The Project has the potential to influence the transmission of water and waste-related diseases within the Afungi Project Site Area and Surrounds (including Senga and Maganja) in the following ways:

- project-induced impacts may increase the risk of water-borne diseases through stress on already limited services. As such, the number of users per water source is an important determinant in overall water quality and a potential indicator of a system or resource suffering from overuse;

- mitigating physical displacement in terms of communities' access to improved water sources to ensure that communities have at least the same access to basic services; and

- the provision of sanitation services in host sites will also be important to consider, so that environmental health challenges in the host sites are not exacerbated by an increased population.

Without mitigation, the intensity would be Medium to High and the extent would be local. The impacts would be felt into the long term if not managed. It is definite that the impact may occur if not effectively mitigated and, coupled with the medium magnitude, a MODERATE significance is expected. The impact can occur from construction into the closure phase.

Mitigation Measures

Proposed Project impact mitigations include, but are not limited to:

- water management programmes and plans, as outlined in other sections of this EIA, to prevent pollution or the deterioration of water quality as a direct consequence of the Project's activities;

- evaluating opportunities to develop an effective surveillance system to monitor the impacts of water and sanitation conditions, in partnership with the local authorities; and

- effective RAP planning and implementation, which includes effective water and sanitation programmes and incorporates PIIM mitigations.

Proposed occupational health and safety mitigations will be outlined in an Occupational Health and Safety Management Plan, and will include:

- water management from the Project Site, including design elements for wastewater and sewerage treatment in the construction and operational phase;

- conducting IEC campaigns in the workforce on proper water use, hygiene and sanitation; and

- providing worker accommodation camps and work areas with sufficient potable water facilities, and conducting monitoring and surveillance activities to ensure water is potable.

Residual Impacts

With effective and sustained mitigation, the intensity would be adjusted to a MODERATE impact. This benefit would be felt at the local level and, if sustained, could be long term in nature, with Medium levels of benefit and would be Likely to occur. Thus, the residual impact would be MODERATE.

Table 13.14 Impacts on Soil, Water and Waste-related Diseases

	Without Mitigation	Residual Impact (with Enhancement)
Construction Phase		
Duration	Short term	Short term
Scale	Local	Local
Severity	High	Medium
Magnitude	High	Medium
Likelihood	Likely	Likely
Significance	**MAJOR**	**MODERATE**
Operational Phase		
Duration	Long term	Long term
Scale	Local	Local
Severity	Medium	Medium
Magnitude	Medium	Medium
Likelihood	Likely	Likely
Significance	**MODERATE**	**MODERATE**

13.5.4 Sexually Transmitted Infections and High-risk Sexual Practices, Including HIV/AIDS

Impact Assessment

The Project has the potential to increase STI and HIV transmission in the Afungi Project Site Area and Surrounds (including Senga and Maganja) leading into Project construction, and along the transport corridors and Palma Town during construction and operations. The contributing factors will be summarised by way of the 'four Ms':

Mobility

- Access into the Afungi Project Site may increase in-migration from the Palma District, adjacent provinces and Tanzania, potentially with high prevalence rates of HIV/STIs, or at least higher than those in the local community.

- An enhanced transport corridor, including new and upgraded roads, will be developed to support Project needs.

- The establishment of mushrooming settlements comprised of camp followers or an in-migrant workforce may emerge in proximity to the Project. If unmanaged, spontaneous settlements can encourage the proliferation of social disharmony and increase the presence of commercial sex workers (CSWs), which may increase high-risk sexual behaviours.

Mixing

- Different population groups such as in-migrants, returning migrants and transport/short-term workers or traders, may arrive and mix with the Project's host communities, and introduce different STIs or viral strains.

Men

- Based on literature and from precedence in similar studies, men are likely to engage in high-risk sexual encounters, especially in a society where women are vulnerable or have limited access to information and health services supporting safe sexual practices and HIV/AIDS awareness.

Money

- Men are more likely to benefit from the direct and indirect opportunities of the Project, whereas women may be considered vulnerable due to limited access to information and education, and limited participation in a cash economy. This may give rise to forms of transactional sex, where women may be enticed into sexual encounters to supplement their household income. There is likely to be an increase in disposable income among the local workforce and in the Project's host communities as a result of Project activities, and this may support an increase in transactional sexual relations and the presence of CSWs.

- HIV/AIDS and associated wellness elements pose a well-known and described business risk in terms of long-term productivity and sustainability within the workforce. It is thus important that effective mitigation measures are developed.

Without mitigation, the intensity would be High and the extent would be regional. The impacts would be of a long-term duration, due to the chronic nature of diseases such as HIV/AIDS. The impact will definitely occur if not effectively mitigated and, coupled with the High magnitude, a MAJOR significance is expected. The potential impact will be highest in the construction phase, but will extend into the operational phase.

Mitigation Measures

Proposed Project impact mitigations include, but are not limited to:

- gathering key data on reproductive health and STIs in the Project area. This will assist to determine a baseline on current knowledge, practices and behaviours as well as prevalence rates;

- developing a clear HIV policy and programme in the workplace. It is important that this framework is established at an early stage, so that the programmes are functional prior to construction;

- preventing the development of spontaneous camps or the expansion of existing communities (camp-follower communities) that are close to the Afungi Project Site and specifically the temporary workers camp (TWC), by speculative migrants; and

- evaluating opportunities to support specific HSS activities in the District.

Proposed occupational health and safety mitigations will be outlined in an Occupational Health and Safety Management Plan, and will include:

- developing HIV and STI management programmes for the workforce, and ensuring that contractors are addressed under the workplace management programmes, with full access to IEC and care and treatment services; and

- encouraging widespread availability and social marketing of condoms in the workplace.

Residual Impacts

With effective and sustained mitigation, the intensity would be adjusted to Medium in the best-case scenario, due to the number of influences that may be beyond the Project's control. The potential impacts may remain in the long term and, with a reduced likelihood and magnitude, may reduce to a moderate impact.

Table 13.15 Impacts on Sexually Transmitted Infections and HIV/AIDS

	Without Mitigation	**Residual Impact (with Mitigation)**
Construction Phase		
Duration	Long term	Long term
Scale	Regional	Regional
Intensity	High	Medium
Magnitude	**High**	**Medium to High**
Likelihood	**Definite**	**Likely**
Significance	**MAJOR**	**MODERATE TO MAJOR**
Operational Phase		
Duration	Long term	Long term
Scale	Regional	Local
Intensity	High	Medium
Magnitude	**High**	**Medium to High**
Likelihood	**Definite**	**Likely**
Significance	**MAJOR**	**MODERATE TO MAJOR**

13.5.5 Food and Nutrition-related Issues

Impact Assessment

The Project has the potential to impact on household nutrition in the Study Area in a number of ways.

- The loss of access to fishing grounds as a direct result of Project activities has the potential to reduce the current fishing production. This may reduce access to fishing grounds, thereby impacting food security through limited opportunities to accessible fishing areas. This can impact household consumption/access to fish at a household level. In addition, fishing forms an important cornerstone in local livelihoods, and reduced access to fish catching may reduce local income opportunities.

- Physical and economic displacement and disruptions will impact local livelihoods and food security, and may impact food availability in the wider Palma District. This may be exacerbated if communities are resettled to areas where there are limited opportunities to replicate their agricultural and fishing livelihood activities, eg if the land available is ineffective for agriculture, or where the soil fertility or access to water for irrigation is insufficient.

- Infectious diseases play a co-morbid role in malnutrition. Malaria and intestinal parasites are major contributors, and improvements in nutritional indicators will be reduced without supplementary programmes in these areas.

- In-migration may impact on nutrition in a number of ways, including:
  - supply and demand effects in the area may impact on food inflation.
  - Limited availability and access to land for subsistence agriculture, especially in areas of unplanned development.

- Change of livelihoods and practices are important, especially if the communities abandon farming in search of alternative sources of livelihoods, specifically employment with the Project. This may limit local food production and erode the practices of farming in the area.

Without mitigation, the impact intensity would be High and the extent would be regional. The impacts would be of a long duration, due to the chronic nature of malnutrition and its impacts on the cognitive development of children in particular. The impact will definitely occur if not effectively mitigated and, coupled with the High magnitude, a MAJOR significance is expected. The potential impact will initiate in the pre-construction phase and will extend into the operational and even closure phase.

Mitigation Measures

Project impact mitigations include, but are not limited to:

- undertaking a baseline nutritional and micronutrient deficiency survey in the Study Area;

- RAP monitoring of communities that have been physically relocated, to track potential challenges related to food production and food security;

- considering supporting IEC programmes in local communities as part of an integrated approach, together with water and sanitation and malaria programmes; and

- supporting programmes that promote local farming practices to increase yields through improved farming techniques. This can effectively promote sustainable livelihoods if supported by promoting access to markets.

The proposed occupational health and safety mitigations will be outlined in an Occupational Health and Safety Management Plan, and will include:

- IEC programmes and nutritional programmes in the workplace that promote proper feeding practices to prevent obesity and non-communicable diseases (NCD).

Residual Impacts

With effective and sustained mitigation, it is possible to achieve a positive impact. This benefit would be felt at the local and even regional level and, if sustained, could result in long-term benefits. There is a likelihood of positive benefits occurring, especially in the operational phase, and the residual impact is assessed to be of MAJOR positive, regarded as a benefit.

Table 13.16 Impacts on Food and Nutrition

	Without Mitigation	**Residual Impact (with Mitigation)**
Construction Phase		
Duration	Long term	Short term
Scale	Regional	Local and even regional
Intensity	High	Medium
Magnitude	**High**	**Medium**
Likelihood	**Definite**	**Likely**
Significance	**MAJOR**	**MODERATE**
Operational Phase		
Duration	Long term	Short term
Scale	Regional	Local and even regional
Intensity	High	Medium to high benefit
Magnitude	**High**	**High**
Likelihood	**Definite**	**Likely**
Significance	**MAJOR**	**MAJOR BENEFIT**

13.5.6 Accidents/Injuries

Impact Assessment

Potential Project impacts such as accidents and injuries within the Afungi Project Site result from:

- road traffic accidents;

- accidents from the increased transportation of equipment, goods and personnel within the Afungi Project Site and roads linking with the Afungi Project Site Area and Surrounds (including Senga and Maganja), and the wider Palma District via existing and new road networks. These will allow public and Project vehicles to drive at higher speeds and encourage a greater frequency and volume of traffic, thereby creating increased potential for road and pedestrian vehicle accidents; and

- increased levels of alcohol and substance abuse, which may occur in the area due to a number of factors, and may result in an increase in road traffic accidents should vehicles be operated under the influence of either.

Without mitigation, the intensity would be High and the scale would be regional, taking into account the transportation networks and corridors linking the Afungi Project Site with local and regional transport corridors. The impacts would be felt into the long term if not effectively managed. Impact likelihood is definite and, if not effectively mitigated, maintains a High magnitude, and a MAJOR significance is expected. The impact can occur from construction into the early closure phase.

Mitigation Measures

Proposed Project mitigations include, but are not limited to:

- developing and effectively communicating a policy for the management of emergencies or accidents in the community as a direct result of the Project's activities. This will be developed as part of the Project's community safety and security management plans and Emergency Response Plan.

Proposed occupational health and safety mitigations will be outlined in an Occupational Health and Safety Management Plan, and will include:

- managing mobile equipment and machinery, which will assessment of their fitness to work as drivers, supported by specific medical surveillance programmes;

- strictly enforcing drug and alcohol policies for all work-related vehicles, including contractor transport vehicles; and

- employee and contractor management for Project transport vehicles. These need to include specific requirements for driver training, rest periods, vehicle roadworthiness, speeding, etc.

Residual Impacts

With effective and sustained mitigation, the intensity would be adjusted to Medium in the best-case scenario, due to the number of influences that may be beyond the Project's control. The potential impacts may remain in the long term and with a reduced likelihood, and magnitude may reduce to Moderate.

Table 13.17 Impacts on Accidents and Injuries

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Short term	Short term
Scale	Regional	Regional
Intensity	High	High
Magnitude	High	High
Likelihood	Definite	Unlikely
Significance	**MAJOR**	**MODERATE**
Operational Phase		
Duration	Long term	Long term
Scale	Regional	Regional
Severity	High	High
Magnitude	**High**	**High**
Likelihood	**Definite**	**Unlikely**
Significance	**MAJOR**	**MODERATE**

13.5.7 Social Determinants of Health

Impact Assessment

The holistic model of health and well-being acknowledges that the health status of a population is affected by factors known as health determinants. These health determinants are many and varied, and are all closely interlinked. Areas that may induce negative health impacts include:

- the influence of PIIM on social determinants of health (SDoH) by impacting on local living conditions, increasing the potential for social disharmony, impacting social networks and placing stress on traditional values and conflict resolution. Competition for scarce resources such as housing, healthcare services, basic services (water and sanitation), food sources, education and potential employment opportunities may increase with in-migration. This may affect community security and contribute to a breakdown in law and order and household/community social norms;

- physical displacement from within the Afungi Project Site, which may alter the sense of place and identity, making social adaptation challenging; and

- the Project's presence may isolate some communities, with an erosion of traditional social networks and, potentially, trading areas.

The development of the Project may also bring about significant positive changes in the local SDoH dynamics, through:

- improved access to work opportunities. Research has shown that improvements in four sectors – namely housing, water/sanitation, transportation (roads) and communication (mobile phone coverage) – can produce a measurable and sustained health and social benefits of up to 50 percent;

- the Project likely supporting areas of improved access, with communication likely to improve as a result of the Project's developments and requirements; and

- improvements in the local economy through increased local workforce opportunities and development. This will support improvements in other sectors, such as improved access to goods and services in the Palma District, improved transportation networks, enhanced communication opportunities through radio, mobile telephone coverage and access to credit.

The intensity of the impact is anticipated to be Medium, recognising a regional influence as development initiatives expand opportunities for residents of the Palma District. The impacts will continue long term, representing a Medium to High magnitude. It is likely that these impacts will occur, proving an overall MODERATE to MAJOR significance ranking. The impact can occur from construction and extend into operations. It is not clear how these may play out into closure, as the social dynamics in the areas are likely to have changed significantly over this period. The confidence is medium.

Mitigation Measures

Proposed Project impact mitigations include, but are not limited to:

- PIIM mitigation measures as part of multidisciplinary planning;

- the effective management of physical and economic displacement to maintain community security, social and cultural networks and promoting access to goods and services;

- evaluating opportunities for local development that support vulnerable groups; and

- effective communication programmes on the activities of the Project and management of expectations of what the Project will and will not do.

Residual Impacts

With effective and sustained mitigation, there is likely to be a positive impact. This benefit would be felt at the local and even regional level and, if sustained, could result in long-term benefits. The likelihood of positive benefits, especially in the operational phase, supports the modelling of residual impacts as a MODERATE POSITIVE.

Table 13.18 Impacts on Social Determinants of Health

	Without Mitigation	Residual Impact (with Enhancement)
Construction Phase		
Duration	Short term	Short term
Scale	Regional	Regional
Intensity	High	Medium
Magnitude	High	Medium
Likelihood	Definite	Likely
Significance	**MAJOR**	**MODERATE**
Operational Phase		
Duration	Long term	Long term
Scale	Regional	Regional
Intensity	High	Medium benefit
Magnitude	High	Medium benefit
Likelihood	Likely	Likely
Significance	**MAJOR**	**MODERATE POSITIVE**

13.5.8 Healthcare Services and Infrastructure

Impact Assessment

Healthcare services and infrastructure in the Afungi Project Site Area and Surrounds (including Senga and Maganja) and the wider Palma District are limited, and the development of the Project may influence healthcare services negatively in a number of ways.

- The development of the Onshore and Near Shore components of the Project may limit access to healthcare services for those communities.

- Resettlement and the physical relocation to new resettlement host sites will need to consider the ability to access healthcare services, and that available facilities have adequate capacity to manage the increasing population size effectively. Referral networks will also need to be considered, to ensure that reduced access to healthcare services occur as a result of resettlement activities.

- PIIM and economic growth and development in the area may stretch the already limited healthcare services in the area, placing stress on the existing services and human resource capacities.

- The Palma District currently has limited healthcare personnel. The Project will require staff to support the occupational health and safety requirements, and care should be taken not to employ a host of medical staff from Palma District or provincial health services in the Project, as this could impact on the delivery to deliver public health services.

Conversely, improved access to rural areas may, in turn, create enhanced access to healthcare services. Better roads may allow entry of public transport and the development of transportation networks and services. Local economic development may also improve the availability of public transport and thus access to referrals health centres.

The intensity of the impact is anticipated to be High, with a regional influence. The impacts will continue into the long term, representing a High-level magnitude. Impact likelihood is definite, thereby creating an overall MAJOR significance ranking. The impact can occur from construction and extend into operations. Economic development and changes in demographics in the Afungi Project Site and wider ADI will likely change during the Project construction and operations, significantly altering the context for impact ranking at Project closure. Therefore, it is currently difficult to predict until further into the Project life cycle.

Mitigation Measures

Proposed Project impact mitigations include, but are not limited to:

- considering supporting access to healthcare services in the Study Area;

- considering the upgrading of Palma Hospital to the level of a district hospital, to cater for population growth in the area; and

- engaging and partnering with the Ministry of Health in these elements, so that the service delivery options are structured appropriately into the national and provincial models.

The proposed occupational health and safety mitigations will be outlined in an Occupational Health and Safety Management Plan, and include:

- developing and designing an appropriate site-based medical service that is managed by a reputable medical service provider; and

- planning and managing the recruitment strategies to employ staff in the workplace medical service so medical staff are not taken from local services within Mozambique.

Residual Impacts

With effective and sustained mitigation, there is likely to be a positive impact. This benefit would be felt at the local and even regional level and, if sustained, could result in long-term benefits. There is a likelihood of positive benefits, especially in the operational phase, which supports the modelling of residual impacts as a MODERATE POSITIVE.

Table 13.19 Impacts on Healthcare Services and Infrastructure

	Without Mitigation	Residual Impact (with Enhancement)
Construction Phase		
Duration	Short term	Short term
Scale	Regional	Regional
Intensity	High	Low
Magnitude	High	Low to Medium
Likelihood	Definite	Likely
Significance	**MAJOR**	**MODERATE**
Operational Phase		
Duration	Long term	Long term
Scale	Regional	Regional
Intensity	High	Medium to High benefit
Magnitude	High	Medium to High benefit
Likelihood	Definite	Likely
Significance	**MAJOR**	**MODERATE TO MAJOR POSITIVE**

13.5.9 Health Programmes and Systems

Impact Assessment

There is currently limited ability to support effective health programmes in the ADI, due to the lack of capacity of local health services. Access plays a major role, in that the bulk of the communities in the ADI are located in remote rural areas.

There is currently no health-focused NGO or donor-funded activity in the Afungi Project Site. The development of the Project may reduce the future interest of agencies to work in the area, as there may be an assumption that the Project would fund any local development so that the NGOs can work elsewhere. This may limit the ability of the District to attract local support for health programmes from aid agencies.

The intensity of the impact is anticipated to be Low with a local influence. The impacts will be long term, representing a Low-level magnitude. It is likely that these impacts will occur, resulting in an impact of MINOR significance. The impact may occur during the construction phase and extend into operations. It is not clear how this may play out into the closure phase, as developments and demographics in the Study Areas are likely to change significantly over this period.

Mitigation Measures

Proposed Project impact mitigations include, but are not limited to:

- evaluating opportunities for HSS that will primarily mitigate impacts, as discussed in the previous sections; and

- supporting the RHMIS, which will allow the Project a mechanism to monitor and evaluate health trends in the Project Area more effectively. At present, the RHMIS is limited by human resource constraints, diagnostic deficiencies and a lack of electronic management systems, as well as poor access to healthcare and health-seeking behaviour in local communities. Supporting an upgrade in this system will provide the most accurate form of longitudinal surveillance mechanism to monitor local health trends. Other options for health monitoring can also be investigated, so that social and economic indicators can be monitored similarly.

Residual Impacts

With effective and sustained mitigation, there is likely to be a positive impact in health programmes in the area, although over the longer term. This benefit would be felt at a local level and, if sustained, could result in long-term benefits. There is a likelihood of positive benefits, especially in the operational phase, which supports the modelling of residual impacts as a MODERATE POSITIVE.

Table 13.20 Impacts on Health Programmes and Services

	Without Mitigation	**Residual Impact (with Mitigation)**
Construction Phase		
Duration	Long term	Short term
Extent	Local	Local
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	**MINOR**	**MINOR**
Operational Phase		
Duration	Long term	Long term
Extent	Local	Local
Intensity	Low	Medium positive
Magnitude	Low	Medium positive
Likelihood	Likely	Likely
Significance	**MINOR**	**MODERATE POSITIVE**

13.6 ECONOMIC IMPACTS

The Project will have a range of positive local, regional and national level economic impacts, including income growth (linked to employment and

procurement opportunities), capacity development and increased government revenue.

The key positive impacts assessed in this section include:

- increased government revenue;
- employment, training and skills development, including corporate social investment by the Project;
- procurement of local goods and services; and
- economic development and economic diversification.

A potential negative impact is associated with unmet community expectations regarding employment and local economic development.

13.6.1 Increased Government Revenue

Impact Assessment

Based on the Project's legal and regulatory framework, Government will receive revenue through mandatory income and discretionary revenue, as summarised below.

Mandatory Income

- Corporate income tax;
- royalties – gas production taxes;
- income from state equity stakes;
- dividend withholding tax;
- excise and sales tax on equipment and services (Mozambique exempt);
- import duties;
- VAT on imported equipment;
- employee taxes;
- social contributions – 1 percent of gas income is allocated to the local community;
- property tax and fee based on land area;

- additional taxes (company, personal and product-related) from links to local suppliers (backward/'upstream' linkages);

- additional taxes (company, personal, product-related) from increased local forward/'downstream' activities related to the gas project (eg local gas distribution, electricity generation, fertiliser manufacturing);

- additional taxes (company, personal and product) from general income increases, due to spending multiplier effects from income earned with direct (project–related) and indirect (supply-linked and downstream processing) activities, and

- payment of environmental licensing fees of 0.01 percent of the investment amount, as prescribed in the Environmental Regulations for Petroleum Operations (Decree No. 56/2010).

Discretionary Revenue

- Income from direct project-based employment;

- income from indirect employment created by suppliers (backward linkages) and newly created downstream processing (forward) activities;

- income from overall increases in income levels, due to spending multiplier effects;

- revenue spent in community/social investment programmes related to the Project, and

- terms and conditions of Master Agreements and Production Sharing Agreements between the Government of Mozambique and the Project, yet to be finalised (Ernst & Young, 2012).

Government will be solely responsible for the allocation of revenue, based on internal Government policies and the country's development needs. The indirect impacts related to Government spending cannot be assessed accurately at this stage, as the allocation of Government revenue to development locally, at provincial level and nationally is unknown.

As a direct result of the Project, Government revenue will continue to increase, and will have a direct positive impact on the national economy. Government spending will, in turn, be experienced as an indirect positive impact by the people of Mozambique. The Project will induce associated growth and development at a national, regional and local scale and the impacts will be felt throughout the Project's lifespan (30 years). The impact will be long term, national in scale and have a High intensity. Given the scale and intensity, a

High magnitude is expected. Coupled with a definite probability of occurrence, a MAJOR POSITIVE impact significance is anticipated.

Enhancement Measures

Mozambique's ability to benefit from the economic opportunities that the Project offers at a national level will depend on good governance, revenue distribution and fiscal transparency. The Project will undertake a Revenue Management Study early in the Project to understand the Mozambican economy better. The Project will work alongside Government and the NGO and donor community throughout the life of the Project, to encourage accountability and revenue distribution to provincial and District-level government within the Project area; particularly in light of Mozambique recently being recognised as being compliant with EITI standards (1).

The Project will facilitate ongoing engagement between relevant stakeholders aligned with the Project's SEP, to encourage revenue distribution to Cabo Delgado Province and Palma District in support of regional and provincial government capacity building, governance, revenue management and civil society empowerment. The Project will facilitate this engagement to enable Government to realise provincial and District-level development plans and objectives and enhance Government's capacity in the execution of its Project-related roles and responsibilities (eg renewal of permits, issuing of licences and approvals, law and order and border control, land-use planning and infrastructure investment, maintenance and budgeting), and to invest effectively in economic and social development initiatives.

Residual Impacts

Overall, the impact on Government revenue is predicted to be positive, long term and experienced at a national level, and will retain MAJOR POSITIVE impact significance.

Table 13.21 Increased Government Revenue

	Without Mitigation	**Residual Impact (Enhancement Measures)**
Construction and Operational Phases		
Duration	Long term	Long term
Extent	National/regional/local	National/regional/local
Intensity	Medium	Medium
Magnitude	**High**	**High**
Likelihood	**Definite**	**Definite**
Significance	**MAJOR POSITIVE**	**MAJOR POSITIVE**

(1) As of 26 October 2012. See www.itie-mozambique.org.

13.6.2 Employment, Training and Skills Development

Impact Assessment

There are high expectations among the local communities in terms of Project employment and training opportunities. However, levels of education and schooling in the Palma District are low, with an estimated 88 percent of the population not achieving any level of educational attainment.

Highly skilled personnel required for the majority of the construction and operation of the Project are generally scarce in Mozambique. There are very limited professional training opportunities in the Province, with less than 3 percent of the District population engaged in formal employment activities, and formal salaried employment uncommon in the Project area. Over 87 percent of the local population relies on traditional agriculture and fishing subsistence livelihoods. The lack of other industries and formal employers across the District translates at present to an inexperienced local workforce with limited capacity.

The Project expects to provide local workforce training to fill the Project's unskilled labour requirements, while a limited number of people will be sufficiently trained to qualify for semi-skilled positions or skilled positions. Local workforce training will be provided by the Project and Contractors to improve skills levels as relevant for the Project, and to create opportunities for the development of local people to be employed in semi-skilled and skilled jobs over the Project's lifespan.

High-potential national candidates for skilled and highly skilled operations phase employment will be identified, and be required to undertake long-term formal education and training and achieve appropriate qualifications to secure operations phase employment. However, given the skilled labour requirements for the construction of the LNG Plant and Associated Onshore, Near Shore and Offshore Facilities, the majority of the skilled and highly skilled workforce is likely to be recruited internationally, with suitably qualified nationals also being considered for the skilled positions.

Employment as a positive impact can be achieved through:

- direct employment (unskilled, semi-skilled, skilled workforce);
- indirect employment with contractors and suppliers; and
- induced employment, as a result of increased spending in the local areas and along the supply chain.

Employment and training benefits will be felt locally (within the Palma District), within the wider Cabo Delgado Province, and nationally. Construction phase employment will be medium term, from 2014 through to 2019. For labour sourced within the Palma District, the impact intensity will

be High, due to an increase in disposable income and training/experience gained. The magnitude will be Medium, due to the limited employment for communities within the Palma District beyond unskilled and, over time, potential semi-skilled opportunities.

At a provincial and national level, the impact intensity is Medium, due to the limited semi-skilled and skilled national workforce, and the magnitude will be Medium, as the skilled national workforce is also limited. The impact occurrence is definite, and given that the Project will create employment and training opportunities for the population, the impact is of MODERATE POSITIVE significance.

During the Project's operations phase, a significantly lower number of direct employment opportunities will be available, due to the skilled and highly skilled workforce requirements of LNG Plant and Associated Facilities operations. Indirectly, there may be unskilled or semi-skilled employment opportunities, associated with economic development as a result of the Project's ongoing presence in the Palma District.

The extent of the impact will range from regional to national level (depending on where the operations phase skilled/trainee workforce is sourced), and employment will be long term. The impact intensity and magnitude will be Low, due to the limited opportunities available to directly impacted communities. The impact occurrence is definite. Overall, the impact is assessed as having MINOR POSITIVE significance.

Enhancement Measures

The Project will develop a National Content Strategy consistent with discussions with Government, which will detail specific employment, training and supplier development initiatives. Specifically, the strategy will determine the Project's objectives and activities to support the recruitment, training and career progression of Mozambican nationals to enable participation in supplier and workforce opportunities associated with the Project. This strategy will be aligned with the Government's economic development, education and workforce development objectives. The Project will provide guidelines regarding its expectations for employment and training to contractors, to encourage recruitment of a locally sourced workforce and the provision of training opportunities.

The following measures will be included in the Project's National Content Strategy and will contribute to employment, training and skills development opportunities:

- The Project will provide guidance to contractors on local labour recruitment procedures to prioritise local employment (including the Afungi Project Site Area and Surrounds) for unskilled labour and, where possible, semi-skilled labour. Unskilled local labour recruitment

procedures will be developed in alignment with Mozambican Labour Law and agreed with provincial and District-level government.

- The Project will provide guidance to contractors regarding labour recruitment, training and employment procedures, as indicated in *Section 13.6* above. This will prohibit the employment of casual workers at the Project site entrance or from village centres.

- The Project and contractors will be required to adhere to formal employment processes, such as registration and the contracting of national workforce at dedicated locations outside the Palma District (eg Pemba and Maputo); utilising online registration for employment for skilled work on the Project website; and clear communication through media (newspapers, online, radio, trade magazines) of recruitment and employment processes, qualifications and eligibility criteria.

- The Project will begin training potential Mozambican candidates as soon as possible for positions during the operational phase. The aim is to maximise the number of Mozambicans employed during the operational phase.

Mitigation measures to discourage an influx of experienced in-migrant workers include:

- the Project will discourage any form of local recruitment office or agency within the Palma District, and will not engage any such entity for workforce recruitment;

- the Project will work with District-level government to develop a local workforce database of directly impacted households and potential candidates for unskilled employment and training opportunities to prioritise local opportunities;

- the Project will develop a local labour recruitment procedure to ensure that contractors are responsible for the selection of their workforce, and that the Project and traditional and appointed village and community leadership will not be directly involved in the selection of local labour; and

- the Project recruitment and employment policies will encourage the employment of women as a means of ensuring gender equality and empowerment.

Residual Impacts

With the implementation of the above mitigation measures, the anticipated impact is likely to remain as MODERATE POSITIVE during the construction. Given the low number of operational phase employees, the operational phase impact would remain as MINOR POSITIVE.

Table 13.22 Employment, Training and Development

	Pre-mitigation	Residual Impact (Enhancement and Mitigation Measures)
Construction Phase		
Duration	Medium term	Long term
Extent	National/regional/local	National/regional/local
Intensity	High (local), Medium (regional)	High (local), Medium (regional)
Magnitude	**Medium**	**Medium**
Likelihood	**Definite**	**Definite**
Significance	**MODERATE POSITIVE**	**MODERATE POSITIVE**
Operational Phase		
Duration	Long term	Long term
Extent	National/regional/local	National/regional/local
Intensity	Medium	Medium
Magnitude	**Low**	**Low**
Likelihood	**Definite**	**Definite**
Significance	**MODERATE POSITIVE**	**MINOR POSITIVE**

13.6.3 Procurement of Local Goods and Services

Impact Assessment

During construction, the Project will provide worker accommodation within the Onshore Project Footprint. The procurement of services and consumables will be managed to ensure that international standards for quality, health and safety are maintained. Consumables (eg food) will need to be purchased in large quantities while meeting stringent quality, health and safety standards. Potential suppliers will have to demonstrate and continue to meet stringent health and safety, quality and other standards and criteria to be considered, and secure Project supplier contracts. To achieve these standards, the Project will support supplier development through the National Content Strategy.

The direct procurement opportunities for district, provincial and national levels will be developed over time. For those companies that meet eligibility criteria, become approved suppliers and get the opportunity to be part of the supply chain, there will be long-lasting and sustained benefits to the businesses and their employees through increased experience, capacity and training, particularly in having to meet more stringent international requirements.

Over time, the potential exists for businesses to develop to meet the procurement needs during the construction and operational phases. The operational phase activities associated with the Facility may provide opportunities for local business growth and development.

Given the current scarcity of suitably resourced and qualified local businesses, the positive impact associated with procurement will be experienced primarily at the regional, national and international level at first. Procurement opportunities during the construction phase will be medium term, and during the operations phase the impact will be long term. This impact will definitely

occur through all Project phases. The magnitude of this impact would be Low at first but has the potential to increase to Medium over the life of the Project, but will be dependent on the successful capacity building of potential suppliers.

The impact is rated as of MINOR POSITIVE significance during the construction phase, with the potential to increase to MODERATE POSITIVE in the long term. While it will be of moderate positive significance during operations, the supply chain will have developed during the construction phase and some businesses will have built the capacity to supply goods and services to the Project and other future projects.

Enhancement Measures

With regard to procurement and supplier development, the Project's National Content Strategy will support capacity building to support Mozambican company participation in securing and successfully delivering Project-related contracts and procurement opportunities, and will be aligned with the Government's economic development objectives. The Project will provide guidelines regarding the Project's expectations for employment and training to contractors, to encourage recruitment of a locally sourced workforce and the provision of training opportunities. The following measures will align with the National Content Strategy and help to contribute to managing supplier and procurement development opportunities:

- The Project will research the capacity and capability of local and national suppliers, and determine supplier development opportunities.

- The Project will develop and make available to potential suppliers information regarding eligibility criteria, requirements and expectations as early as possible to enable potential suppliers to understand Project's procurement expectations.

- With the support of the wider extractives industry sector, the Project will facilitate engagement with industry, educational and training institutions, central, provincial and District-level government to identify supplier development and capacity-building opportunities, training and qualifications to establish an approved national supplier database.

Residual Impacts

Assuming that the above enhancement measures are implemented, the anticipated impact on procurement is likely to increase over time to MODERATE POSITIVE significance during the construction phase. During the operational phase, the impact significance would continue to MODERATE POSITIVE.

Table 13.23 Procurement of Local Goods and Services

	Without Enhancement	With Enhancement
Construction Phase		
Duration	Long term	Long term
Extent	National/regional/local	National/regional/local
Intensity	Low	Medium
Magnitude	**Low**	**Medium**
Likelihood	**Definite**	**Definite**
Significance	**MINOR POSITIVE**	**MODERATE POSITIVE**
Operational Phase		
Duration	Long term	Long term
Extent	National/regional/local	National/regional/local
Intensity	Medium	Medium
Magnitude	**Medium**	**Medium**
Likelihood	**Definite**	**Definite**
Significance	**MODERATE POSITIVE**	**MODERATE POSITIVE**

13.6.4 Unmet Community Expectations for Employment and Procurement Opportunities

Impact Assessment

There are high expectations around the employment opportunities associated with the Project. In the context of employment and the limited skills, experience and opportunities for local communities, there will likely be unmet expectations. There are also expectations for the procurement of goods and services locally and regionally. If these opportunities are not available because suppliers are unable to meet eligibility criteria or do not have the experience and capacity to compete for opportunities, there may be disappointment, anger and resentment towards the Project due to unmet expectations and the limited capacity to participate in Project opportunities.

The impact will be mainly localised to the communities around the Afungi Project Site. This will be a short to medium–term impact. The intensity of the impact will be Medium to High, as people might feel that the Project has not benefited them. The impact will definitely occur, and the magnitude rating is expected to be moderate. Overall, the impact is rated as being of a MODERATE significance.

Mitigation Measures

- The Project will develop a National Content Strategy consistent with discussions with Government and will communicate its strategies and objectives at local, regional and national level to reinforce realistic expectations around employment and procurement opportunities.

- The Project will develop and make available to potential suppliers information regarding eligibility criteria, requirements and expectations to enable potential suppliers to understand the Project's procurement expectations.

- The Project will report on local workforce recruitment, training and employment data and local procurement activities to District-level and provincial government, to document local capacity-building achievements and contributions to local economic development.

- A SEP will be implemented to ensure fair recruitment from different communities.

- The Project will maintain a Grievance Mechanism to address community grievances around local employment and procurement. The Grievance Mechanism will outline procedures for the resolution of grievances such as holding discussions with the communities to determine possible solutions, and will ensure an assessment of the community's satisfaction with the resolution or grievance closure takes place.

Residual Impacts

The magnitude of the impact is expected to be Medium post-mitigation. The residual impact will have MODERATE significance.

Table 13.24 Impacts on Unmet Expectations for Employment

Impact	Pre-mitigation	Residual (Post-mitigation)
	All Phases	
Duration	Long term	Long term
Extent	Local to regional	Local to regional
Intensity	Low	Low
Magnitude	**High**	**Medium**
Likelihood	**Definitely**	**Likely**
Significance	**MODERATE**	**MODERATE**

13.6.5 Economic Diversification

Impact Assessment

As the Project develops, the increased demand for goods and services from the Project, employees and immigrants may create commercial opportunities for local businesses. This may then result in diversification of the economy of the broader Project area, its supply chain and in the businesses providing goods and services to the growing population.

Over the medium term, however, larger enterprises may to be established in the District and region to provide goods and services. Although construction activities will provide much opportunity for economic and business development, other constraints such as access to finance, limited infrastructure and skills, a limited private sector in the area and the current prevalence of subsistence farming, will continue to constrain the level and sophistication of local development.

As summarised in *Section 13.4* PIIM may bring people with different experiences, knowledge and demands that will supplement the existing economic and livelihood activities and offer additional activities that serve to diversify the local economy. However, much of the income earned by in-migrant populations is likely to leave the Project area in the form of remittances to their families.

Economic development and diversification will mostly be experienced as a positive impact for some stakeholders (ie those who understand and value the change and development, including those participating in a cash economy and therefore able to participate effectively). However, economic development and diversification is less accessible for those reliant on subsistence livelihoods, not participating actively in a cash economy, vulnerable and/or excluded from participation for various socio-economic reasons including capacity/education or experience.

This impact will be direct as it is related to the Project's activities and demands, and indirect as it is related to improvements to local infrastructure associated with District-level government revenue management and investment associated with increased economic development in the District.

The impact will begin during the construction phase and will continue for the duration of the Project and potentially beyond (where linked to other resource development initiatives in the District/regional and associated sustainable business and economic development initiatives). Therefore, the impact duration is potentially permanent. The potential for economic diversification can occur at the local and regional level. The impact will definitely occur. The overall magnitude of this impact will be Medium for the life of the Project. The significance level of the impact will be MODERATE POSITIVE for all phases of the Project.

It has been noted that areas in Palma Bay have been designated as marine reserves for aquaculture in cages and seaweed production in terms of Decree no. 71/2011 of 30 December. However, there is currently no seaweed production or aquaculture in Palma Bay and we are not aware of imminent plans to begin such. The construction and operation of the Project will likely preclude the use of the bay for aquaculture. This is not considered significant as the Decree allows for other socio-economic projects to be undertaken within these reserves if they present comparative advantages. The economic benefit of the Project is considered to be more beneficial than the potential future use of the bay for aquaculture.

Enhancement Measures

The main objective of these enhancement measures is to support economic diversification in the District and region through:

- recognising public sector leadership and mandated responsibilities for economic development and diversification, and facilitating engagement

with central, provincial and District-level representatives to understand the private sector role in supporting achievement in government policies, plans and objectives;

- aligning the Project's national content initiatives with national policy and facilitating engagement with provincial and District-level government to align Project activities with the regional and District-level economic and social development objectives outlined in provincial and District Development Plans;

- effective implementation of the Project's National Content Strategy supporting employment and procurement opportunities (*Sections 13.6.2* and *13.6.3*); and

- encouraging transparency and accountability in the management and distribution of Project revenue to support District and regional initiatives.

Residual Impacts

With the implementation of the above enhancement measures, the anticipated impact will remain as MODERATE POSITIVE significance during all phases of the Project.

Table 13.25 Economic Development and Economic Diversification

	Pre-mitigation	Residual Impact (Enhancement Measures)
	All Phases	
Duration	Long term to permanent	Long term to permanent
Extent	National	National/regional/local
Intensity	Medium	Medium
Magnitude	**Low**	**Medium**
Likelihood	**Likely**	**Likely**
Significance	**MODERATE POSITIVE**	**MODERATE POSITIVE**

13.7 SHIPPING AND NAVIGATION

13.7.1 Impact of the Project Vessels and Activity on International Maritime Traffic

Impact Assessment

The Mozambique Channel is an international waterway with no fixed, formally established sea lanes. All international traffic passes outside the Project Offshore Area.

During the construction phase, the subsea infrastructure will be laid within the Golfinho, Prosperidade and Mamba gas fields. As these fields do not cross international maritime routes (see *Figure 13.4*), it is expected that there will be no interference with international maritime traffic. The impact during the construction phase is, therefore, expected to be local and temporary, with a

Negligible intensity. Impact magnitude is expected to be Negligible. The Negligible magnitude and unlikely probability of occurrence results in a NEGLIGIBLE significance impact during the construction phase.

23°30'0"E 29°0'0"E 34°30'0"E 40°0'0"E 45°30'0"E 51°0'0"E

2°0'0"S 7°30'0"S 13°0'0"S 18°30'0"S 24°0'0"S

Uganda
Kenya
Somalia
Rwanda
Burundi
Congo (Democratic Republic of the)
Tanzania
Seychelles
Comoros
Angola
Malawi
Zambia
Mozambique
Zimbabwe
Madagascar
Namibia
Botswana
South Africa
Swaziland
Lesotho

18°0'0"E 23°30'0"E 29°0'0"E 34°30'0"E 40°0'0"E 45°30'0"E 51°0'0"E

Legend

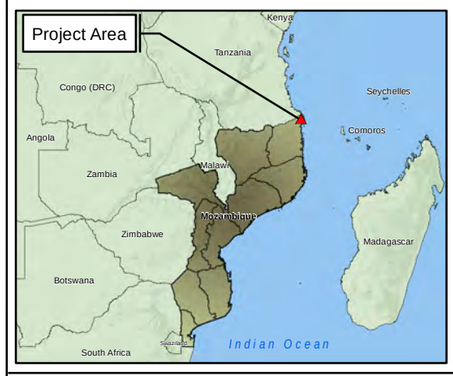
Maritime Traffic Distribution Routes

- Traffic from Persia Gulf to Africa, Americas and Europe
- Traffic of trans-shipments of Oil
- Trans-shipments of general cargo

- Area 1
- Area 4

Mozambique Provincial Boundary

- Inhambane
- Manica
- Sofala
- Maputo
- Tete
- Gaza
- Cabo Delgado
- Niassa
- Nampula
- Zambezia



MAIN MAP SCALE:

0 100 200 300 400 500

Kilometers

N

TITLE:

Figure 13.4:
Present Maritime Traffic Distribution Routes in the Mozambique Channel

CLIENT:

Anadarko
Moçambique Área 1, Lda
eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 12 400 000

DRAWING: Maritime Traffic Distribution Routes Moz Channel.mxd

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Impacto Projectos e Estudos Ambientais

ERM

Projection: UTM Zone 37 S Datum: WGS84
Source: DIVA-GIS. Impacto, 2012.
Inset Map: Esri Data & Maps

SIZE: A3

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During the operational phase, LNG Carriers servicing the LNG Facility will contribute to the international traffic, but will not create traffic congestion in the international maritime routes. The extent of the impact is expected to be local with a long-term duration, but Low intensity. The magnitude of the impact is thus expected to be Negligible to Low during the operational phase. Coupled with a likely probability of occurrence, the significance is expected to be MINOR.

Mitigation Measures

The Project supports the implementation of good international industry practice and compliance with national and international maritime legislation. The Project will develop a Traffic and Transport Procedure for all phases of the Project, in liaison with the relevant maritime authority. This plan will include a Navigation Warning Scheme, the schedule of vessel movements, speed limits as well as the size and duration of the exclusion zones. The management plan will ensure clear communication of activities, especially during the operations phase, due to the nature of the LNG Carrier cargo and industry maritime pollution, health and safety performance expectations.

Residual Impacts

The residual impact is likely to be NEGLIGIBLE during construction and MINOR during the operational phase.

Table 13.26 Impact of the Project Vessels and Activity on International Maritime Traffic

	Without Mitigation	**Residual Impact (with Mitigation)**
	Construction Phase	
Duration	Temporary	Temporary
Extent	Local	Local
Intensity	Negligible	Negligible
Magnitude	**Negligible**	**Negligible**
Likelihood	**Unlikely**	**Unlikely**
Significance	**NEGLIGIBLE**	**NEGLIGIBLE**
	Operational Phase	
Duration	Short term	Short term
Extent	Local	Local
Intensity	Low	Low
Magnitude	**Low**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MINOR**	**MINOR**

13.7.2 Disruption of Commercial Fishing Activities

Impact Assessment

In the areas where the Offshore Project activities take place, there is low commercial fishing activity. The Offshore Project activities will be primarily focused in the vicinity of Golfinho, Prosperidade gas fields in Area 1 and Mamba Gas Field in Area 4, between 50 and 70km from the coast in deepwaters. Commercial fishing efforts are limited within Area 1 and 4, and

mostly occur in the south-west around the Bank of São Lázaro. Commercial fishing is seasonal and the position of the fishing grounds is dependent on the main concentrations of sighted species, which varies throughout the year. Commercial vessels do pass through the Area 1 and Area 4 en route to fishing locations.

Commercial fishing vessels may be affected by Offshore Project activities, including vessels associated with the drilling of offshore wells, installation of the subsea infrastructure and the movement of service vessels (construction and operational). In addition, a 5km radius safety exclusion zone around drill rigs impede access to desired commercial fishing grounds. This impact will be a short to medium–term regional impact. During construction, there will be a high number of vessels traversing the area, thus the intensity will be Low, as the levels of adaptability will be dependent on effective communication between the Project and the Maritime Authority (INAMAR). The impact is of Likely occurrence and of Low magnitude. The impact is rated as being of MINOR significance during the construction phase.

During operations, the number of Project-related vessels will be reduced and will likely cause a limited disruption for other vessels. Construction safety exclusion zones will be removed, while the mobile safety exclusion zones supporting vessel movement will remain, as will specific exclusion zones around Offshore Facilities. During the operational phase, the impact will be long term with a Negligible to Low intensity. The impact is unlikely to occur, and it will be of NEGLIGIBLE significance.

Mitigation Measures

The Project will develop a Traffic and Transport Procedure for all phases of the Project, with the objectives of minimising damage to fishing equipment (such as fishing nets) and maintaining engagement between the Project, Maritime Authorities, National Fisheries Administration (ADNAP) (1) and operators of international fishing vessels. This plan will outline procedures to undertake the following activities.

- The Project will engage with the Maritime Authority and provide relevant information to maintain awareness of the Project and commercial fishing activities in Area 1 and Area 4 among relevant stakeholders.

- The Project will ensure that all its service and construction vessels are equipped with functional radar equipment, and that the radar system is continuously monitored.

- Where possible, safety exclusion zones shall be clearly noted and/or monitored, to enable vessels to be aware when they are close to the safety

(1) Agency responsible for implementing the commercial and licensing agreements of the fleets

zones, and appropriate pilot vessels, coastguards and maritime support agreed between the Project, Maritime Authorities and ADNAP.

- The Project will collaborate with Maritime Authorities and ADNAP to establish a Grievance Procedure for reporting grievances related to maritime activities through appropriate communication and engagement with relevant stakeholders.

- The Project shall take into account the actions defined in the *Plano Estratégico de Desenvolvimento da Pescaria de Atum em Moçambique* (PEDPA) (Strategic Development Plan for Tuna Fisheries) as discussed in *Section 9.7.6*.

Residual Impacts

Implementation of the above-mentioned mitigation measures will enable the residual impact significance to reduce from MINOR to NEGLIGIBLE during the construction phase, as commercial fishers are made aware of the presence of Project vessels and the exclusion zones, allowing them to fish elsewhere. During operations, the significance will remain as NEGLIGIBLE.

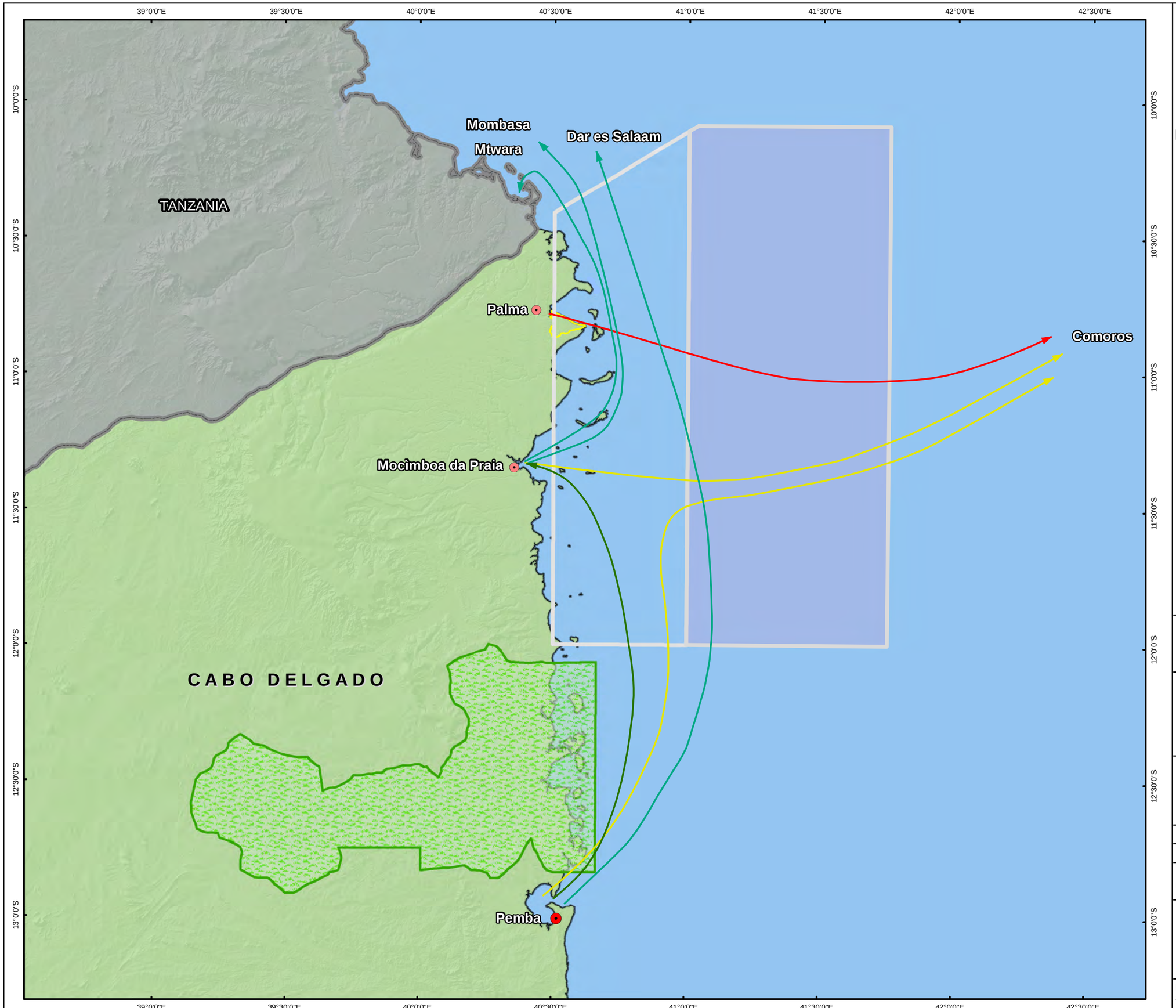
Table 13.27 Disruption of Commercial Fishing Activities

	Without Mitigation	**Residual Impact (with Mitigation)**
Construction Phase		
Duration	Short to medium term	Long term
Extent	International to regional	Regional
Intensity	Low	Low
Magnitude	**Low**	**Low**
Likelihood	**Likely**	**Unlikely**
Significance	**MINOR**	**NEGLIGIBLE**
Operational Phase		
Duration	Long term	Long term
Extent	Regional	Regional
Intensity	Negligible	Negligible
Magnitude	**Low**	**Low**
Likelihood	**Unlikely**	**Unlikely**
Significance	**NEGLIGIBLE**	**NEGLIGIBLE**

13.7.3 Impact of the Project Vessels and Activity on National and Regional Cabotage

Impact Assessment

Area 1 and Area 4 are used by national and regional cabotage and shipping, and comprises low-intensity traffic to and from Madagascar, Comoros, Tanzania and Kenya, connecting the ports of Pemba and Mocímboa da Praia as shown in *Figure 13.5*.

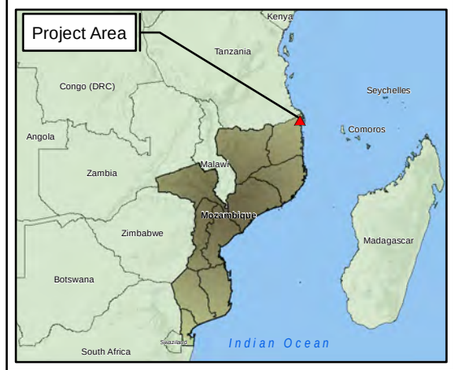


Legend

- Capital City of Cabo Delgado
- Town
- Afungi Project Site
- Boundary with Tanzania
- Cabo Delgado Province
- Quirimbas National Park
- Area 1
- Area 4

Cabotage Routes

- Domestic Cabotage
- Regional Cabotage: Comoros
- Regional Cabotage: Tanzania and Kenya
- Informal Traffic: Mozambique-Comoros



MAIN MAP SCALE:

0 20 40 60 80

Kilometers

N

TITLE:

Figure 13.5: National and Regional Cabotage Routes

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DRAWING: National and Regional Cabotage Routes in Area 1.mxd

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During the construction phase, there will be safety and security exclusion zones around Project vessels undertaking drilling and subsea infrastructure placement. Maritime traffic in the Offshore Project Footprint Area will continue, but will need to avoid these exclusion zones. In Palma Bay, laying of the pipeline and dredging activities may delay cabotage vessels wanting to enter the bay, as will the arrival of vessels transporting construction material and equipment, which will be brought to the Pioneer Dock and MPD by sea. As such, access will be impeded at times, resulting in increased travel distance by vessels to traverse around exclusion zones, delays to access the bay/landing sites due to mobile exclusion zones, and waiting time to access areas to avoid crossing into exclusion zones.

Given the volume of cabotage traffic, the impact of loss of access to traversing/landing sites and the duration of the construction activities, a site-specific, temporary and Medium intensity and Medium magnitude impact is expected, with a Likely occurrence. This results in a MODERATE significance impact.

During the operational phase, LNG Carriers will be entering the bay and there will be various support vessels (eg pilot vessels and coastguards) guiding the carriers into and out of the Export Terminal and to manage the safety and security exclusion zones that will be maintained around vessels and Near Shore Project infrastructure. Cabotage into and around Palma Bay can continue, although vessels will need to avoid the exclusion zones. The Project support vessels and the LNG Carriers will operate according to conditions set by the Maritime Authority.

The impact is site-specific and long term, and intensity would range from Low during operation of two LNG trains, increasing to Medium as the number of LNG Trains increases to six later in the life of the Project. The magnitude of the impact is Medium with a Definite probability of occurrence. The significance of the impact during the operational phase is, therefore, expected to be MODERATE.

Mitigation Measures

- The vessels involved in dredging and other construction-related activities must be equipped with navigation equipment and suitable aids (such as buoys and lights) to minimise interference with other vessels and to maintain high visibility at all times.

- Appropriate marine terminal systems, protocols and procedures aligned with national and international industry standards and maritime legislation will be developed for the life of the Project and adapted when operating circumstances change (ie as more LNG Trains become operational and increased LNG Carrier traffic into the Export Terminal facilities is planned), in collaboration with the Maritime Authority (INAMAR) and INAHINA.

- There will be ongoing engagement with stakeholders from the shipping national and regional cabotage sector regarding maritime activities, and to communicate specific Project information, eg exclusion zones.

- The Project and INAMAR will develop mechanisms for regular Project communication regarding information exchange and the adoption of adjustments on safety procedures that may be deemed necessary.

Residual Impacts

During all phases of the Project, the residual impact on marine traffic is expected to be MINOR. The proposed mitigation measures will help to manage the operational phase impact on current traffic and, over time, cabotage routes will be adapted to accommodate maritime traffic associated with the Project. This will reduce the probability of the impact occurring, but expected to be MINOR.

Table 13.28 Impacts of the Project Vessels and Activity on National and Regional Cabotage

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Extent	Site-specific	Site-specific
Duration	Temporary	Temporary
Intensity	Medium	Low
Magnitude	**Medium**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MODERATE**	**MINOR**
Operational Phase		
Extent	Site-specific	Site-specific
Duration	Long term	Long term
Intensity	Medium	Low
Magnitude	**Medium**	**Low**
Likelihood	**Likely**	**Likely**
Significance	**MINOR**	**MINOR**

13.8 ONSHORE ARCHAEOLOGY AND CULTURAL HERITAGE

This section identifies potential Project impacts on onshore archaeological and cultural heritage sites; offshore sites are discussed in *Section 13.9.* Cultural heritage sites are those that represent a record of past or present human activity and which are finite, irreplaceable and non-renewable.

13.8.1 Impact of Disturbance of or Damage to Archaeological and Cultural Heritage Sites

Impact Assessment

The archaeology and cultural heritage of Afungi Peninsula, where the Onshore Project Footprint Area is located, is strongly influenced by a number of cultures, including Swahili culture from the 10th century and the Sultanate of Tungi from the 18th century to late 19th century. Important sites in the

region are Tungi, Kiwiya and Mbuizi, located on Cabo Delgado Peninsula, approximately 12km north of the Afungi Project Site Area and Surrounds (including Senga and Maganja).

The Kiwiya settlement on Cabo Delgado Peninsula consists of land holdings of the former Sultanate of Tungi families that date back to the late 19th century. The greater part of them were expropriated during colonial times and families moved to Afungi Peninsula (Quitupo and Maganja). Most families currently remaining on Afungi Peninsula retain a very strong historical and cultural bond with the land. Inhabitants within the 7,000ha Afungi Project Site Area and Surrounds (including Senga and Maganja) will be permanently displaced, resulting in a permanent loss of land and leading to the loss of historical and cultural links to the area.

Ten archaeological sites were recorded within Afungi Peninsula, as well as one abandoned sacred place and several burial sites – see *Figure 13.6*. Most of these sites have been affected by extensive cultivation, and those closer to the coast have been influenced by sea erosion. Sites 15 (Ngodje 1) and 18 (Maganja 2) are considered to be of high heritage significance. Of these two sites of high heritage significance, only site 15 (Ndogje 1) falls within the Onshore Project Footprint Area.

During the construction phase, site clearance activities within the Onshore Project Footprint will include vegetation clearing, de-mining and site levelling, and in the wider Afungi Project Site will interfere with or destroy archaeological resources (most of which have low heritage significance). Most of the archaeological sites within the Afungi Project Site Area and Surrounds (including Senga and Maganja) consist of surface or very shallow deposits of artefacts, which will be exposed to irreversible fragmentation and destruction during construction activities.

It is unlikely that de-mining or construction vehicle operators will notice or avoid scattered potsherds when driving in the area. The impact is expected to be concentrated onsite and will be permanent, with a Medium magnitude and Definite likelihood of occurrence. Consequently, without mitigation, this impact is expected to be of MINOR to MODERATE significance.

Leading into the operational phase, the Onshore Project Footprint will have been cleared and excavated, and the LNG Plant and Associated Facilities constructed on the site. Any artefacts of cultural or heritage significance uncovered during these activities would be removed from the site, and those with low or negligible heritage significance destroyed during construction activities. As such, during the operations phase, the impact significance will be NEGLIGIBLE**.**

40°20'0"E
40°30'0"E
40°40'0"E
40°50'0"E
41°0'0"E
10°30'0"S
10°40'0"S
10°50'0"S
11°0'0"S

TANZANIA
Quionga
Assame
Calomba
Issa
Nkalanga
Macala
Senga
Nkumbi
Matapata
Aienda
Bawala
Olumbe
Quiwia
Palma
Quitupo
Maganja
Tungi Bay
Cabo Delgado Peninsula
Tecomaji Island
Afungi Peninsula
Rongui Island

A
7. Mbuizi 1
5. Mbuizi 2
Tungi
9. Mosque
8. Kiwiya (Village)
10. Tungi 2
11. Tungi 1
Quiwia

B
12. Palma 2
13. Palma1
14. Shell Midden
Palma

C
15. Ngodje 1
16. Ngodje 2
29. Kitupo 1
30. Kitupo 2
31. Kitupo 3
32. Kitupo 4
Quitupo
17. Maganja 1
18. Maganja 2
19. Old Maganja
20. Maganja 3

Legend

- Villages / Settlements
- Sites of Archaeological Importance
- Survey Tracks
- Regional Roads
- Afungi Project Site

Project Area
Indian Ocean

MAIN MAP SCALE:
0 5 10 15
Kilometers
N

TITLE:

Figure 13.6: Archaeology Survey Area and Location of Sites

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Mitigation Measures

The mitigation measures proposed below focus on the construction phase as site clearances, excavation and construction activities would disturb the land insofar as required to construct the LNG Plant and Associated Facilities. As such, any cultural heritage and archaeological artefacts will be uncovered during this process. However, some are also applicable to the operational phase.

- Adopt a participatory approach with communities directly impacted by Project activities to agree how archaeological and cultural heritage sites will be identified, sites such as burial grounds or areas with intangible but traditional significance are appropriately blessed before physical displacement, and chance finds communicated to traditional and appointed village leadership and religious leaders to respect sociocultural and faith-based traditions.

- The Project will develop a Chance Finds Procedure to define the processes aligned with relevant national laws and regulations, local customs and traditional norms that must be followed to ensure appropriate treatment of a chance find, and to minimise disruption to construction activities, including:
  - developing training and awareness material to educate Project staff and contractors in the identification of archaeological material; and
  - developing procedures for contractors to report chance finds to the Project.

- Undertake a detailed archaeological rescue investigation of Ngodje 1 (site 15) to determine the future archaeological management of the site. This should include the development of a 50m-perimeter fence around the site, given its high archaeological significance.

- The Project will have an experienced archaeologist present for the duration of the construction period to advise on and monitor construction activities, to avoid damage to cultural sites and undertake training for all contractors regarding implementation of the Chance Finds Procedure.

- Create an awareness programme for Project staff regarding tangible and intangible cultural heritage, to raise awareness of how to interact with different cultural environments within the Project context, thereby reducing the probability of conflict and cultural heritage destruction.

The Project will investigate methods for commemorating any artefacts or sites identified, including erecting and maintaining plaques with information on the sites.

Residual Impacts

The residual impact significance is likely to be reduced to MINOR in the construction phase, if appropriate mitigation measures are implemented. During operations, the impact will be NEGLIGIBLE, as it can be expected that any activities that could have an impact on the archaeological sites would have ceased.

Table 13.29 Impact of Disturbance of or Damage to Archaeological and Cultural Heritage Sites

	Without Mitigation	Residual Impact (with Mitigation)
Construction Phase		
Duration	Permanent	Permanent
Extent	Onsite	Onsite
Intensity	Medium	Low
Magnitude	**Medium**	**Low**
Likelihood	**Definite**	**Definite**
Significance	**MODERATE**	**MINOR**
Operational Phase		
Duration	Permanent	Permanent
Extent	Onsite	Onsite
Intensity	Low	Low
Magnitude	**Low**	**Low**
Likelihood	**Unlikely**	**Unlikely**
Significance	**NEGLIGIBLE**	**NEGLIGIBLE**

13.9 MARINE ARCHAEOLOGY AND CULTURAL HERITAGE

13.9.1 Impact of Offshore and Near Shore Construction and Operational Activities on Marine Archaeology and Cultural Heritage

Impact Assessment

Palma (or Tungi) Bay was used as an important natural harbour for the anchorage of vessels travelling to the old trading centre located on Vamizi Island (1). Therefore, it is quite possible that there are ship remains within the Offshore Project Footprint Area, or archaeological anomalies of anthropogenic origin lying on the seafloor.

Marine geophysical and Autonomous Underwater Vehicle (AUV) data along the pipeline route have shown that no large man-made structures are apparent in the survey data. Based on investigations to date, there are no known archaeological or cultural heritage sites along the pipeline corridor or in the region of any subsea infrastructure.

The proposed construction phase activities (eg pipeline laying, anchoring of lay barges and support vessels, seabed interventions such as dredging and trenching) will impact the seabed. During the operational phase, any

(1) As described by Ahmad bin Majid in the 15th century.

intermittent maintenance activities to ensure pipeline integrity are likely to cause similar impacts. During construction, the use of DP rigs and ROV surveys reduce the likelihood of damaging sites of cultural heritage in the Offshore gas fields. Increased vessel traffic in Palma Bay during the operational phase is not expected to impact cultural heritage, as these vessels will be anchoring in surveyed territory.

Should an artefact of potential cultural value be discovered, it is expected that impact significance will be Negligible. The extent would be local, and permanent. Impact magnitude is expected to be Medium. Since the probability of this impact occurring is rated as Unlikely, impact significance will be MINOR.

Mitigation Measures

In the deepwater offshore, the Project will use an AUV to examine the seabed prior to drilling or laying of the subsea infrastructure or pipelines. Similarly, in the shallower waters of the near shore, from the continental shelf to Afungi Peninsula, an ROV will be used to examine the seabed. During these surveys, if an artefact of potential cultural value is detected then the Chance Finds Procedure described in *Section 13.8* will apply, and the following mitigations implemented:

- The location of the artefact will be mapped and, if necessary, the object will be scanned and visually inspected by AUV or ROV.

- Where possible, the Project will avoid the cultural heritage artefact so that it is not damaged by construction or operations activities.

- The Project will engage an experienced archaeologist to advise on and monitor offshore construction activities to avoid damage to cultural sites and undertake training for all contractors regarding implementation of the Chance Finds Procedure for offshore activities.

Residual Impacts

In the unlikely case that previously unidentified artefacts are damaged by the Project during construction and operations, the Chance Finds Procedure will be implemented. Impact intensity and magnitude will be Low, with an Unlikely occurrence, and significance will be NEGLIGIBLE.

Table 13.30 Impact of Offshore and Near Shore Construction and Operational Activities (Including Drilling) on Marine Archaeology and Cultural Heritage Sites

	Without Mitigation	**Residual Impact (with Mitigation)**
	Construction Phase	
Duration	Permanent	Permanent
Extent	Local	Local
Intensity	Medium	Low
Magnitude	**Medium**	**Low**
Likelihood	**Unlikely**	**Unlikely**

	Without Mitigation	Residual Impact (with Mitigation)
Significance	**MINOR**	**NEGLIGIBLE**
Operational Phase		
Duration	Permanent	Permanent
Extent	Local	Local
Intensity	Medium	Low
Magnitude	**Medium**	**Low**
Likelihood	**Unlikely**	**Unlikely**
Significance	**MINOR**	**NEGLIGIBLE**

13.10 INDIRECT SOCIO-ECONOMIC IMPACTS AT PEMBA AND MOCIMBOA DA PRAIA

13.10.1 Impact Assessment Overview

The focus of the Project activities will take place in the Afungi Project Site and Palma District. Hence, this is where the impacts will be predominantly experienced. Indirect impacts at Pemba (being the closest port to Palma) and Mocimboa da Praia (MdP) are nonetheless acknowledged. AMA1 and eni currently make use of existing port facilities to support the Project in Palma and are likely to continue to do so for drilling operations, and some initial import of materials and equipment. AMA1 currently has a camp at MdP. The Project's activities at Pemba are expected to decrease over time once the port facilities (including customs operations) at Palma are constructed. There is also the potential for future industrial or other services to establish themselves at Pemba to support the Project. This is an indirect impact that the Project cannot directly control.

Due to the unquantifiable nature of future growth of Pemba town and port and MdP, potential impacts at Pemba and MdP are described qualitatively at a high level. Future growth may take the form of an expansion to Pemba Port, expansion of the Pemba town or MdP town (hotels, houses, etc) and expansion of infrastructure and services (eg roads, water, waste, electricity, etc). The population of Pemba and MdP may increase as more people move there seeking employment or related economic opportunity. As this and other projects are developed in northern Mozambique, Pemba and MdP are likely to see growth resulting in both positive and negative impacts. On the positive side, Pemba and MdP may experience economic growth, increase in tourism and infrastructure development. On the negative side, existing social infrastructure (eg health care) and physical infrastructure (eg electricity, transport routes, the port) may come under increased pressure.

13.10.2 Mitigation/ Enhancement Measures

The Project will comply with the relevant laws and regulations (including EIA regulations) when undertaking any new activity in Pemba or MdP. The Project will also abide by any spatial development plan or strategy developed by the Government of Mozambique for Cabo Degado Province's future growth.

Chapter 14

Unplanned Events

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14 UNPLANNED EVENTS

14.1 INTRODUCTION

An unplanned event is defined as 'a reasonably foreseeable event that is not planned to occur as part of the Project, but which may conceivably occur as a result of Project activities (eg accidents), even with a low probability'. Unplanned events may occur during any phase of the Project. This chapter describes the potential unplanned events associated with the Project and provides an assessment of the potential impacts on the receiving environment. Incidents such as minor spills and leaks that tend to occur on any project site during normal activities are considered and assessed in *Chapters 11* to *13*.

The Engineering and EIA Teams have considered a variety of potential unplanned events that may occur throughout the phases of the Project, and have developed a range of design features to reduce the likelihood of such events occurring. A variety of management plans (see *Chapter 17* and *Annex D* to *Annex F*) and mitigation measures have been developed to further reduce potential impacts to the onshore and marine environment. A representative Emergency Response Plan (ERP) is provided in *Annex H*. The ERP defines an organizational structure and provides a framework for responding to a major unplanned event. These proactive measures all serve to reduce the likelihood, extent and duration of adverse impacts resulting from an unplanned event.

Most of the foreseeable unplanned events associated with the Onshore and Near Shore Project components would be readily handled by these management plans, reducing the risk of an event occurring or the significance of any impact should an event occur. However, the vast area covered by the Offshore Project and difficult access to the subsea infrastructure on the seabed hinder an immediate response, should an unplanned event occur. This chapter therefore discusses risks associated with the following unplanned events:

- large volume spills of chemicals or hydrocarbons (1) (see *Section 14.3*); and
- failure of subsea infrastructure (such as well blowout (2) or pipeline failure) (see *Section 14.4*).

Other scenarios may occur during any phase of the Project, with the potential for environmental or social impacts. Such rare events include major fires and explosions, storage tank failures or ruptures, flare ignition failures and production shutdowns due to extreme weather conditions. While it is outside the scope of this EIA to assess quantitatively the probability and outcome of

(1) The activities covered by this EIA are for LNG production from natural gas, and are not anticipated to produce any crude oil. Consequently, the term 'hydrocarbon 'is used to describe the various fuels and condensate from this natural gas production.
(2) A well blowout is an uncontrolled flow of reservoir fluids into the well bore, and sometimes to the surface.

such events, it is appropriate to consider the management of certain scenarios, as they have potentially important environmental, socio-economic and community health and safety implications. Management measures to avoid the risk of such scenarios are presented in *Section 14.5*.

To further reduce the likelihood of unplanned events occurring, a Safety Case / Risk Assessments (1) will be undertaken as part of the FEED process. This will make provision for the identification, assessment, mitigation and management of health and safety hazards and risks associated with the Project. The findings will not only be used to reduce the likelihood of the occurrence of unplanned events, but also to refine and update the management plans and ERP to help the Project manage these risks.

14.2 METHODOLOGY

14.2.1 Assessing Significance of Risks

The methodology used to assess the risks associated with unplanned events differs from the impact assessment methodology set out in *Chapter 3* of this EIA. Impacts resulting from unplanned events are defined as being a combination of the likelihood (or frequency) of incident occurrence and the consequences of the incident should it occur. The assessment of likelihood takes a qualitative approach based on professional judgement, experience from similar projects and interaction with the Engineering Team. The assessment of consequence is based on specialists' input and professional experience (from the respective specialist disciplines) gained from similar projects.

Definitions used in the assessment for likelihood and consequence are set out in *Box 14.1.*

(1) Safety Case / Risk Assessments are formal processes to demonstrate that the Project has achieved ALARP for each safety-related aspect of the Project.

Box 14.1 Significance Criteria for Unplanned Events

Likelihood
Likelihood describes the probability of an event or incident actually occurring or taking place. It is considered in terms of the following variables:

- **Low**: the event or incident is reported in the oil and gas industry, but rarely occurs;
- **Medium**: the event or incident does occur but is not common; and/or
- **High**: the event or incident is likely to occur several times during the Project's lifetime.

Consequence
The potential consequence of an impact occurring is a culmination of those factors that determine the magnitude of the unplanned impact (in terms of the extent, duration and intensity of the impact). Consequence in unplanned events is similar to magnitude of planned events (see *Chapter 3*) and is classified as either a:

- **minor consequence**: impacts of Low intensity to receptors/resources across a local extent, that can readily recover in the short term with little or no recovery/remediation measures required;
- **moderate consequence**: impacts of Low to Medium intensity across a local to regional extent, to receptors/resources that can recover in the short term to medium term with the intervention of recovery/remediation measures; or
- **major consequence**: exceeds acceptable limits and standards, is of Medium to High intensity affecting receptors/resources across a regional to international extent that will recover in the long term only with the implementation of significant/remediation measures.

Once a rating is determined for likelihood and consequence, the risk matrix in *Table 14.1* is used to determine the impact risk significance for unplanned events. The prediction takes into account the mitigation and/or risk control measures that are already an integral part of the Project design, and the management plans to be implemented by the Project.

Table 14.1 Unplanned Events Risk Significance

Risk Significance Rating				
	Likelihood	Low	Medium	High
Consequence	Minor	Minor	Minor	Moderate
	Moderate	Minor	Moderate	Major
	Major	Moderate	Major	Major

Table 3.7 in *Chapter 3* outlines the definitions of impact significance for planned Project activities. The definitions of MINOR, MODERATE and MAJOR significance are also applicable for unplanned events.

It is not possible to eliminate completely the risk of unplanned events occurring. However, the mitigation strategy to minimise the risk of the occurrence of unplanned events is outlined in *Box 14.2*.

Box 14.2 Mitigation Strategy for Unplanned Events

Control: aims to prevent an incident happening or reduce the risk of it happening to ALARP through:

- reducing the likelihood of the event (eg preventative maintenance regimes, reducing chemical usage, traffic calming and speed limits, community road safety awareness training, implementation of state-of-the-art blowout preventative equipment, procedures and training);
- reducing the consequence (eg bunds to contain spilled fuels, fire protection); and
- a combination of both of these.

Recovery/remediation: includes contingency plans and response, eg:

- ERPs (including an Oil Spill Contingency Plan).

14.3 ASSESSMENT OF SPILLS OF CHEMICALS AND HYDROCARBONS

14.3.1 Overview

Spillages of chemicals, hydrocarbons and other fluids are considered unplanned events with the potential for significant environmental or social effects. Various substances will be stored and used in bulk during the various Project phases, including:

- chemicals:
  - drilling mud;
  - monoethylene glycol (MEG);
  - corrosion inhibitors and biocides;
  - methanol;
  - refrigerants;
  - solvents; and
  - fertiliser and similar chemicals; and
- hydrocarbons:
  - diesel and fuel oil;
  - aviation fuel;
  - lubricating and hydraulic oils; and
  - condensate.

14.3.2 Onshore Spills of Chemicals and Hydrocarbons

The above-mentioned chemicals (excluding drilling mud) will be used and stored onshore; however, the Project design, management plans and mitigation measures (outlined in *Chapter 12*) minimise the risk of adverse impacts resulting from an unplanned event such as a spill. For example, the LNG Process Area will be curbed to confine spills of potentially hazardous materials, and storage areas will be bunded to contain any potential spill to prevent them from impacting adjacent areas. Spill containment and clean-up

kits will be available and, in the event of a spill, clean-up will occur as soon as possible after the spill, using appropriate response and safety equipment. Following clean-up, the materials will be stored in appropriate containers (eg drums) and will be managed according to the WMP (see *Annex E*) if they cannot be reused or recycled. In addition, the LNG Process Area will have a dedicated stormwater treatment system (see *Chapter 4*). This system will be designed to treat potentially contaminated run-off water to the applicable standards, prior to discharge into Palma Bay.

The features of the Project design and actions to be taken by Project staff in the event of a spill are anticipated to prevent spills of potentially hazardous materials from impacting onshore receptors. Furthermore, the safety exclusion zones around the Project infrastructure and activities prevent local communities from being directly affected by a spill onshore. The consequences of spills within the Onshore Project Area are, therefore, not assessed in detail, although their causes are discussed and relevant mitigation and management measures are proposed (see *Section 14.3.7*).

14.3.3 Offshore Spills of Chemicals and Hydrocarbons

The majority of the chemicals and hydrocarbon fluids mentioned in *Section 14.3.1* will be used in the Offshore Project Area and in Palma Bay. Spills to the marine environment (within Palma Bay or offshore) could occur during all phases of the Project, due to the malfunction or failure of equipment, vessel collision or human error during transfer or use of such fluids. The following sections provide an overview of potential chemical or hydrocarbon spills to the marine environment.

Chemical Spills

Chemical spills to the marine environment have the potential to occur during the transfer, storage and use of chemicals or in the case of equipment failure (eg release of hydrostatic test water). The impacts associated with chemical spills are related to the nature of the chemical spilled, location (surface or subsea) of spill volume and its behaviour in the marine environment (sink, float, disperse, etc). Drilling chemicals such as drilling muds (which contain barite and bentonite), cement, methanol and MEG will likely be stored in bulk on the drill rigs. These are classified as having low toxicity and have been rated as 'Pose Little or No Risk to the Environment' (PLONAR) (1). Other chemicals (such as solvents) that may not be PLONAR rated will be stored and used in smaller quantities and therefore have a lower risk of impact to the marine environment. Chemicals such as biocides and corrosion inhibitors are classed as having low toxicity in the dilution rates to be used.

In the event of a chemical spill to the marine environment, the chemical would be subject to dispersion and dilution by prevailing currents. The appropriate

(1) The OSPAR List of Substances Used and Discharged Offshore which Are Considered to Pose Little or No Risk to the Environment (OSPAR Agreement 2012-06).

response will depend upon the specifics of the event, including the characteristics of the material spilled, volume, location of spill and environmental conditions at the time of spill (current and wind direction and speed, etc). The Emergency Response Plan will address appropriate responses for the higher-risk chemical spill scenarios in the marine environment.

Spills will likely result in a temporary and highly localised decline in water quality. Such spills are likely to present a limited potential for toxicity to marine organisms, due to temporary exposure and low toxicity as a result of rapid dilution. The impacts associated with such a chemical spill are not considered further; however, measures to minimise the likelihood of chemical spills and management procedures to address such spills are outlined in *Section 14.3.7*.

Hydrocarbon Spills

The Project recognises the category of spills with the highest likelihood of occurrences is hydrocarbons, such as fuels and condensate. Crude oil is not expected to be produced from the offshore wells or stored/transported by the Project; therefore, the likelihood or potential impacts resulting from a spill of crude oil are not considered. A summary of the characteristics and behaviour of these hydrocarbons if spilled in the marine environment are presented below.

14.3.4 Behaviour of Hydrocarbon Spills in Water

Following the release of hydrocarbons into water, a number of processes occur that influence the fate of the spill. These processes are affected by the chemical and physical properties of the hydrocarbons such as its density, chemical composition (eg relative proportions of different hydrocarbons), viscosity, flash point, etc. The most important processes to affect hydrocarbons following a spill are dispersion and weathering. These processes are described in more detail below.

- **Spreading**: tendency to spread on the water surface. This is primarily a function of the viscosity of the hydrocarbon and is affected by temperature.

- **Drift**: the effect of tidal currents and wind. Hydrocarbons will drift at the speed and direction of the tidal current.

- **Weathering**: a complex series of physical, chemical and biological processes by which the volume of the hydrocarbon on the water surface reduces. The principal mechanisms involved in weathering are as follows, and examples of the potential impacts to environmental and social receptors and resources from major hydrocarbon spills are illustrated in *Figure 14.1* and *Figure 14.2*:

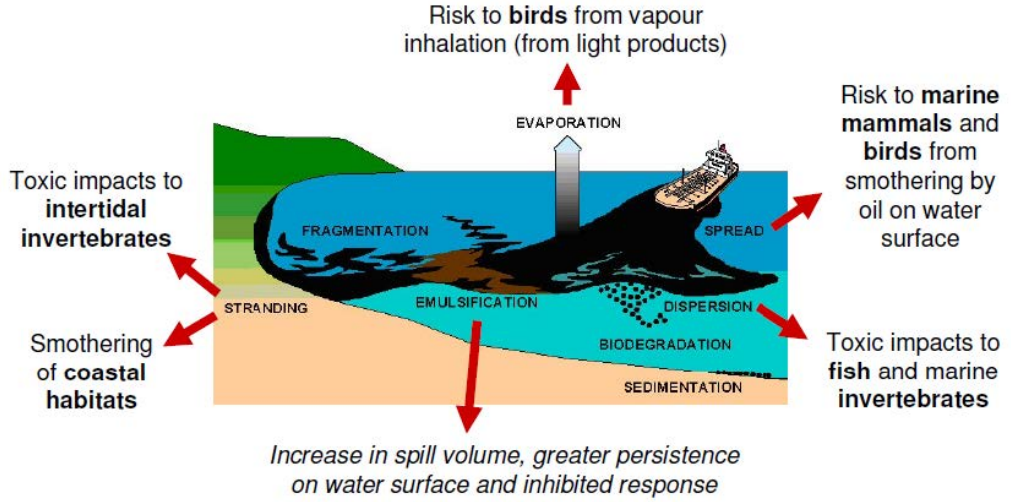
    - **evaporation**: loss of light, low molecular weight fractions;

- **emulsification**: combining with water to form a hydrocarbon/water emulsion;

- **dispersion**: breaking up of the slick into small droplets, which combine with suspended particles and allow the hydrocarbon to be dispersed in the water column and ultimately to sink to the seabed; and

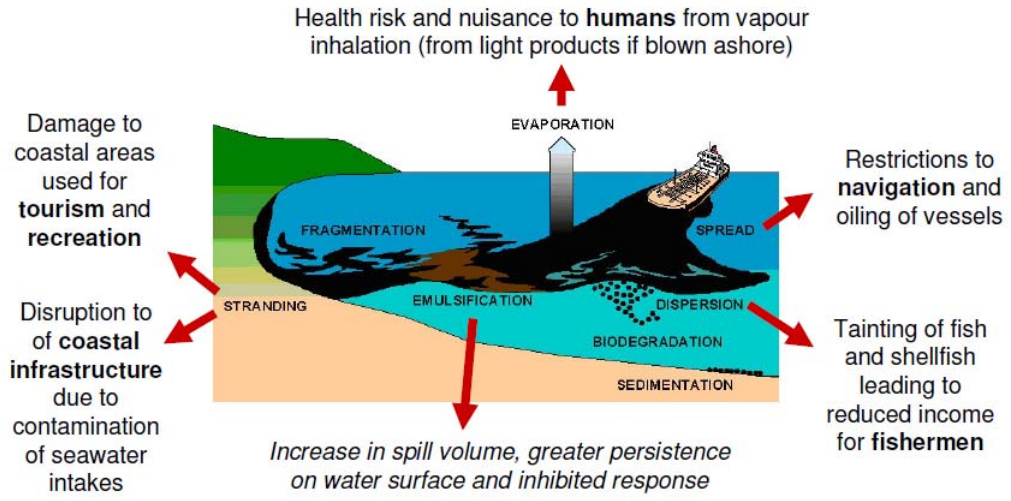
- **oxidation**: chemical/biological processes that break down the hydrocarbon.

Figure 14.1 Example of Potential Ecological Impacts of Major Hydrocarbon Spills



Source: ERM, 2012.

Figure 14.2 Example of Potential Social Impacts of Major Hydrocarbon Spills



Source: ERM, 2012.

The relative importance of these mechanisms is determined by the characteristics of the hydrocarbon spilled and the ambient conditions. The following discussion provides an overview of the characteristics of the hydrocarbons likely to be in use, stored or transported in the marine environment.

Diesel is a low-viscosity fuel that will be used for many engine applications including onshore and offshore construction equipment, vessels, machinery and power generation equipment. Diesel contains a relatively high proportion of volatile light fractions, which will weather and degrade relatively quickly if spilled. Diesel will spread rapidly, with the slick oriented in the direction of the prevailing wind and waves. Evaporation is the dominant process contributing to the removal of the lighter fractions of spilled diesel. The warm prevailing air and sea temperatures present in northern Mozambique are likely to enhance this evaporative loss. Heavier components of diesel tend to persist longer and will tend to disperse as oil droplets in the upper layers of the water column.

Aviation gasoline and jet fuel will be stored near the airport, but are likely to be transported to the Project site by sea. Aviation gasoline and jet fuel are composed of light hydrocarbon fractions; therefore, if spilled in the marine environment, they will evaporate quickly. Both aviation gasoline and jet fuel are toxic to aquatic organisms (1).

Lubricating and hydraulic oil are used in a variety of equipment on vessels and drill rigs. Hydraulic oil is of a light to moderate viscosity and has a rapid spreading rate; therefore it generally dissipates quickly. Lubricating oil is more viscous than diesel and slightly more dense. Lubricating oil is a heavy oil and has few lighter fractions, is therefore more viscous and will weather more slowly than diesel or hydraulic oil. It is less toxic than diesel but will form thicker slicks on the sea surface and therefore be more likely to present a direct impact to marine organisms due to coating.

Synthetic drilling mud is also similar to diesel in terms of physical characteristics, but is less toxic and will disperse more readily (Neff, McKelvie & Ayers, 2000).

Condensate is a hydrocarbon liquid with low viscosity that will generally spread rapidly on the sea surface and evaporate to a greater extent and more quickly than diesel. The rapid spread and evaporation will result in the rapid dissipation of a condensate slick. Spilled condensate will have a low tendency to form an emulsion.

Recovery from a hydrocarbon spill depends on two factors:

(1) Material Safety Data Sheets for jet fuel (eg JET A-1, fuel for aviation turbine engines fitted to aircraft) and aviation gasoline (eg AVGAS 100LL, a low lead content aviation gasoline fuel for piston engine aircraft).

- rate and degree of removal or weathering of the hydrocarbon from the environment; and

- recovery of affected populations and habitats.

Section 14.3.5 discusses the results of preliminary hydrocarbon spill modelling. A detailed spill model will be used to update the Oil Spill Contingency Plan (OSCP) within the ERP, to further develop a plan that is adequate to address potential spills into the marine environment.

14.3.5 Hydrocarbon Spill Modelling

Prior to undertaking exploratory drilling in Area 1, AMA1 commissioned a consultancy, namely The Response Group, to undertake preliminary trajectory modelling for various locations within Area 1 based on spills of 5,000bbl (795m^3) of medium crude oil (1). Trajectory modelling is used to predict the route of a hydrocarbon slick over time and to estimate the weathering profile under specified hydrodynamic and meteorological conditions. Modelling outputs include the predicted slick trajectory and estimates of slick volume, dispersion, emulsification and evaporation over time.

Historical wind data was obtained(2) to run hydrocarbon spill simulations with start points at/near the exploratory drill well sites over various months of the year, taking into consideration the prevalent winds for both the dry and wet seasons. The outputs allow the determination of which waters and shorelines are most at risk during various times of the year, and also illustrate the time taken for hydrocarbon to reach the shoreline. Results showed that spills of 5,000bbl of medium crude oil at the Barquentine, Lagosta and Atum well fields could reach the shore in 15 hours to seven days. Initial shoreline impact for all scenarios modelled at these locations is approximately 150km south of Afungi Peninsula, approximately 80km north of Pemba.

Additional spill modelling will be undertaken prior to the commencement of Project activities (see *Section 14.3.7*) to determine additional spill scenarios. This will include various hydrocarbon types, such as diesel and condensate, as the Project recognises that spills of these hydrocarbons have the highest likelihood of occurrences.

The findings of such modelling will be used to update the OSCP within the ERP to develop a plan that is adequate to address potential spills into the marine environment.

(1) Large volumes of crude oil will not be extracted, stored or transported by the Project. However, medium crude oil was selected for the model as a conservative approach prior to exploration drilling (when it was unknown whether there would be natural gas or crude oil present).
(2) From the Department of Defence Pilot Charts.

14.3.6 Risks to Receptors/Resources from a Hydrocarbon Spill

Potential Impacts to Marine Habitats and Fauna

At any stage of natural gas field development, or during the operational phase, there is the possibility that a major hydrocarbon spill could occur through a vessel collision (possibly releasing fuel oil) or that a refuelling accident could release diesel fuel into the marine environment. In general, the impacts of diesel or condensate spills will be very localised and of relatively short duration, whereas fuel oil may be more persistent. The likelihood of such an occurrence taking place would be low, but the potential consequence could be major, dependent on the sensitivity and importance of receptors affected. The potential impact on marine life of a major spill of hydrocarbons either offshore or in Palma Bay is assessed below.

The environmental receptors considered vulnerable to the potential effects of a spill, and reasoning for this, are:

- **Fish and invertebrates**: toxicity or oxygen depletion as the hydrocarbons degrade may directly affect various life stages of fish and invertebrates (eg eggs, juveniles, adults, etc).

- **Seabird populations**: species that may be at risk from spilt hydrocarbons include diving birds and/or birds that may alight on the sea surface, such as frigate birds and terns.

- **Marine turtle populations**: because turtles do not appear to demonstrate avoidance behaviour for hydrocarbon slicks, they may be exposed to spills at sea. The primary agents for lethal effects on turtles are complete covering by hydrocarbons for juveniles, or the ingestion of tar balls (Milton et al., 2008). Neither should be caused by diesel, as it does not emulsify. Prolonged exposure (days) may generate respiratory-linked pathologies such as reduced dive times and foraging success, with increased risk of starvation.

- **Cetaceans**: whales and dolphins may be affected by a spill, either by effects on mating/courting behaviour or on their food sources. In most cases, these species would tend to move away from the affected area and would not suffer long-term effects. Because of the conservation status of these fauna, even low-level impacts are considered to be of international concern.

- **Corals and seagrass**: emulsified hydrocarbons may directly affect corals by smothering and toxicity, although the potential for the latter decreases with increasing emulsion. Seagrass beds may be affected by hydrocarbon coating, which can inhibit photosynthesis and cause direct toxic effects.

- **Mangroves and mudflats**: these low-energy environments tend to retain hydrocarbons for long periods of time, potentially becoming chronically

contaminated and affecting the associated flora and fauna. The physical effects of hydrocarbons on mangrove species (eg covering or blocking of specialised tissues for respiration or salt management) can be as damaging to mangroves due to the inherent toxicity of the hydrocarbon (Hoff, 2002). Spills entering these environments, particularly mangrove forests, are difficult to clean up without physically damaging the environment in the process.

- **Sand beaches**: may be impacted by hydrocarbon spills, with consequences for various ecological processes (eg impacts on turtles nesting or birds feeding).

In the event of a spill, hydrocarbon can have toxic and/or smothering effects on organisms in the path of the spill, on the sea surface and in the water column. Impacts could extend from an onsite scale to a regional or international scale, based on material spilled, volumes/location/sea conditions and similar factors. Impacts would extend over a short-term period in this climate, as hydrocarbons could be expected to weather or evaporate within weeks; immediate response and clean-up activities would shorten this duration. However, the impact intensity would be High. In particular, coral, mangroves, mudflats, seagrass, marine birds and cetaceans are considered to be highly sensitive receptors to spills. These receptors may recover from a spill, but only with significant management response or remediation measures, depending on the hydrocarbon type and volume. Considering a worst-case scenario, the consequence of a large-volume hydrocarbon spill has the potential to be major. However, the likelihood of a large-volume hydrocarbon spill occurring is Low, and thus the risk significance of the impact is deemed to be MODERATE.

Table 14.2 Impact of Hydrocarbon Spills on Marine Habitats and Fauna

Receptor/ Resource	**Marine Habitats and Fauna**
Extent	Onsite to international
Duration	Short term to medium term
Intensity	High
Consequence	**Major**
Likelihood	**Low**
Risk significance	**MODERATE**

Potential Impacts to Socio-economic Environment

Spills can cause direct damage to fishing resources through toxic effects and tainting, and by disrupting normal fishing activities (eg fouling of nets, vessels). Direct economic losses to the fishing industry due to a hydrocarbon spill can be significant and have both long-term and short-term effects. Hydrocarbon spills can have four main impacts on fisheries resources and fishing activity:

- direct mortality of fish stock (both wild and caged) (1);
- exclusion from the fishing grounds or temporary closure of aquaculture farms;
- fouling of fishing gear; and
- potential decline in market value due to concerns about tainting.

The coastal communities in Cabo Delgado Province are heavily dependent on subsistence fishing for their nutritional well-being. Given that subsistence activities occur throughout the region, it is assumed that potential hydrocarbon spill locations near coastal or island communities in the province could significantly affect subsistence activities. Areas of Palma Bay have been designated for aquaculture development (see *Chapter 9*). Although there are currently no known proposed or active aquaculture farms within the bay, a hydrocarbon spill would likely result in closures.

A large hydrocarbon spill can adversely affect the fishing industry and subsistence fishing through the creation of exclusion zones around the pollution source, thus limiting the access of fishing vessels. As with potential environmental impacts, socio-economic impacts could extend from onsite to a regional or international scale (depending on the material spilled, volume and environmental conditions). The duration would likely be short term, lasting through clean-up and hydrocarbon weathering. Fishing would likely resume post clean-up; however, there may be a potential decline in market value due to concerns about tainting. Therefore, a medium-term impact is possible. Depending on the location of the spill, impact intensity may be High. In a worst-case scenario, impact consequence would be major because a relatively large area of the coastline and sea may be affected. However, the likelihood of a spill occurring is Low; therefore, the overall risk significance of the impact is considered MODERATE.

Table 14.3 Impact of Hydrocarbon Spills on Fisheries and Subsistence

Receptor/ Resource	Fisheries and Subsistence
Extent	Regional to international
Duration	Short term to medium term
Intensity	High
Consequence	**Major**
Likelihood	**Low**
Risk significance	**MODERATE**

Tourism in the Quirimbas Archipelago is dependent on the relatively pristine marine environment. A hydrocarbon spill could have an adverse effect on tourism through a direct impact on coastal areas (including damage resulting from hydrocarbon coating of coral reefs, beaches, etc) or through a belief that the Quirimbas Archipelago are no longer a desirable destination because of a real or perceived loss in pristine wilderness values. A large hydrocarbon spill

(1) There are currently no known proposed or active aquaculture farms within the bay however, approximately 10ha of the bay was declared as a 'Marine Reserve' by Decree no. 71/2011 for aquaculture potential; namely, fish farming and seaweed production (INAQUA, 2011).

is likely to limit tourism-based leisure activities (such as swimming, sailing, fishing, snorkelling and diving) until the area recovers. The duration of the impact could range from days to years, depending upon the specific parameters of the spill event.

The extent of the impact is anticipated to be national, given the importance of tourism in the Quirimbas Archipelago to the national economy, and of short-term to medium-term duration (ie from days to up to five years). The impact intensity has the potential to be High in the event that a spill directly strikes the islands, coastline or the natural resources on which the tourism industry is dependent (eg coral reefs). Impact consequence could be moderate to major as the value/sensitivity of the tourist industry is considered to be High; however, the impact is reversible. The likelihood of a large spill occurring is Low, resulting in an overall risk significance of MODERATE.

Table 14.4 Impact of Hydrocarbon Spills on Tourism

Receptor/ Resource	Tourism
Extent	National
Duration	Short term to medium term
Intensity	High
Consequence	**Moderate to major**
Likelihood	**Low**
Risk significance	**MODERATE**

14.3.7 Risk Prevention and Response Measures

Mitigation of chemical and hydrocarbon spills takes two forms: spill prevention and spill response. The primary mitigation measure for avoiding the impacts of a spill is to prevent any such spill taking place in the first place. This is done through the application of technology and operational controls. The Project will implement systems to respond, contain and clean up all spills. These systems will be designed with the capacity to handle various types and volumes of spills, in line with good industry practices.

The proposed measures to prevent and respond to chemical and hydrocarbon spills are:

- During the procurement process, chemicals will be evaluated for environmental, safety and technical performance. As far as practical, least hazardous chemicals will be selected.

- Procedures for response to chemical spills will be included in the ERP. This will include locations of spill containment and recovery equipment.

- The Project will conduct a detailed technical risk assessment. Such a risk assessment would include modelling and consider:

    - the location, eg in the vicinity of the well fields;

- the event, eg a collision with a bunkering vessel;
- the spill type and volume, eg 100,000l of diesel; and
- the pathway or location affected, eg direct to sea.

- A detailed consequence analysis will be undertaken following spill modelling to determine the potential environmental and socio-economic impact. The analysis will focus on the spill size, type(s) of material spilled and potential spill location(s). Results will be incorporated into the ERP and the OSCP to inform risk reduction options, and to be adopted before construction activity begins.

- Implement the ERP, including an OSCP for offshore and near shore spills, and follow appropriate guidelines such as those produced by the OGP and International Association of Drilling Contractors (IADC) and the United Nations Environment Programme (UNEP). The following specific measures should be incorporated into the plans:

  - incorporate hydrocarbon spill prevention measures into operational procedures for construction, operation and decommissioning;

  - adopt specific controls for vessel offloading, bunkering and equipment refuelling;

  - use reinforced hosing for fuel transfers and use shut-off valves to reduce losses to sea should rupture occur;

  - where possible and practical, refuel only in calm weather and sea conditions and during daylight;

  - inform other users of the sea about the exact timing and location of drilling, construction, operational or decommissioning activities through the issuing of Notices to Mariners via the National Maritime Institute (INAMAR), to prevent the risk of vessel collisions;

  - security vessels should intercept and redirect any vessels potentially entering the various designated exclusion zones established in terms of the Law of the Sea;

  - standard communication (constant bridge watch and radio contact) and navigation systems (lighting and signalling systems) must be used on all vessels;

  - immediately inform INP and MICOA of any significant spills, and implement the OSCP as appropriate; and

  - if required, apply only biodegradable dispersants that have previously been approved by the relevant authority in Mozambique.

14.4 BLOWOUTS AND SUBSEA INFRASTRUCTURE FAILURE/RUPTURE

14.4.1 Introduction

Well blowouts are a potential risk associated with offshore drilling. A blowout occurs when control of the reservoir fluids into a well bore is lost, and these materials (hydrocarbons, drilling mud, etc) enter the environment. Reservoir fluids in the Golfinho, Prosperidade and Mamba gas fields that would be released to the marine environment in the unlikely event of a blowout include a mixture of natural gas, condensate and produced water (1). The main factors contributing to blowouts are leaks behind casing flows after cementing, equipment failure, casing failure, formation fracture, swabbing and stuck pipes (Minerals Management Service, 2007). During drilling and completion operations, all wells will be equipped with a BOP, consisting of a special assembly of high-pressure valves fitted to the top of a well to prevent high-pressure reservoir fluids from escaping. Blowouts are rare events and, with the implementation of proper risk prevention measures (see *Section 14.4.2*), the risk of a blowout resulting in a spill of reservoir fluids into the marine environment is rare.

Another potential unplanned event may result from damage to the subsea infrastructure, in particular the pipelines or wellheads. Such an event could potentially result in the failure of the system to contain its contents. Potential interactions that may lead to damage or rupture the Subsea Production System and pipelines are detailed below.

- Dropped objects/anchor drag: depending on the size and type of a dropped object (or size of anchor from ships crossing or travelling along the pipelines' route), there is a risk of indentation and/or possible failure.

- Sinking and grounding ships: outside of Palma Bay, the pipeline corridor coincides with the Mozambican shipping channel. There is, therefore, a potential risk of ships sinking and subsequently impacting the unburied portions of the subsea pipelines. In the event that the sinking of a cargo ship were to collide with the subsea pipeline, it is likely to result in a natural gas release or potentially, as a worst-case scenario, a pipeline rupture. However, in the shallow waters of Palma Bay, where the grounding of ships can occur, the pipelines will be buried and the likelihood of grounding ships impacting the pipelines is Low.

- Seismic activity or unstable seabed: the risk of pipeline rupture is increased where pipelines are located across deepwater canyons on the seafloor, given the potential instability of such canyons. Similarly, the Project is located in a seismically active area and, should an earthquake occur, the pipeline is at risk of damage.

(1) The exact composition of the mixture is dependent upon the reservoir being drilled.

Significant damage to the subsea infrastructure may cause failure, resulting in a leak or rupture and the subsequent release of large volumes of natural gas, produced water and smaller volumes of condensate. In the event of a pipeline rupture, the pipeline inlet valve would be closed automatically. Other subsea infrastructure will be equipped with similar shut-off valves. This will to minimise the volumes spilled to the marine environment.

Natural gas is composed largely of methane (CH_4) with trace amounts of higher molecular weight compounds such as ethane, propane, butane and pentane, but may also contain hydrogen sulphide (sour gas, H_2S). In sea water in the presence of oxygen, methane oxidises to carbon dioxide and water (H_2O). However, in a pipeline rupture, approximately 85 percent of the CH_4 released will reach the atmosphere, as the fraction oxidised in the water column amounts to 5 to 15 percent (Ward et al., 1987). In the event of a pipeline rupture, the natural gas will bubble to the surface, where the gas will disperse into the atmosphere. The nature of the dispersion (gas cloud) will depend on the molecular weight and the meteorological conditions.

Hydrogen sulphide is a toxic gas and may be present in natural gas; however, the H_2S content of the natural gas within Golfinho, Prosperidade and Mamba gas fields is negligible. Therefore, the associated environmental risks of an H_2S release into the marine environment are considered to be low. The remaining risks to the marine environment, in the event of a pipeline rupture, are associated with methane, condensate and trace amounts of MEG, methanol and water. Volumes of these in any release would be dependent on the rupture location, ambient pressure and flow rates through the subsea infrastructure, as flow rates affect how liquid accumulates in the pipelines.

The Subsea Production System and pipelines will be designed to withstand pressures well above normal operating pressure, and will be tested extensively during commissioning. The likelihood or frequency of a blowout or rupture event occurring and the subsequent release of natural gas is thus very low, based upon the engineering principles and techniques employed in the design of the pipelines and subsea infrastructure (see *Chapter 4*), but nevertheless the possibility still exists.

14.4.2 Risks to Receptors/Resources from Blowouts or Subsea Infrastructure Failure/ Rupture

Potential Impacts to Air Quality

No impact to the physical processes of the Mozambican channel (eg underwater current flows and water exchange) is expected to result from a blowout or pipeline rupture, as the natural gas will disperse into the water, form a gas plume and subsequently disperse into the atmosphere. This impact is therefore not assessed further.

A blowout or failure of subsea infrastructure may result in a contribution to Mozambique's annual emissions of GHGs in terms of global warming

potential. The extent of the impact is national, as Mozambique's GHG emissions would be increased. The duration of the impact is regarded as permanent, given the long residence time of GHGs in the atmosphere. The likelihood of the event/incidence occurring is Low. Given the procedures in place to prevent a significant gas release and the measures to reduce the severity of a blowout or failure, the likelihood of the impact is considered Low and the consequence is considered minor. The overall risk significance of the impact is thus MINOR.

Table 14.5 Impact of Blowouts or Pipeline Failure/Rupture on Mozambique's National GHG Emissions

Receptor/ Resource	National GHG Emissions
Extent	National
Duration	Permanent
Intensity	Low
Consequence	**Minor**
Likelihood	**Low**
Risk significance	**MINOR**

Potential Impacts to Marine Ecology – Water Quality

A blowout or failure of subsea infrastructure could result in the release of large quantities of natural gas, condensate and trace amounts of chemicals into the marine environment. Chemicals (MEG and biocides) will be in use in such dilute quantities that their release is not likely to have a toxic effect on the marine environment. The remaining constituents likely to be released in such an unplanned event are discussed below.

As stated previously, natural gas is composed largely of methane. In the event of a release, the methane will escape into the atmosphere, with a minor amount dissolving into the water column (due to the low solubility of methane). The dissolved methane will be oxidised to carbon dioxide and water, resulting in low to non-existent toxicity on the water column. Considering the behaviour of methane in water and the negligible hydrogen sulphide content of the natural gas, the impact on marine ecological processes in the water column through toxicity effects will be negligible.

Condensate represents the greatest risk to the marine environment in the event of a blowout or the failure of subsea infrastructure. The impact of a large-scale condensate release would be similar to the impacts described in *Section 14.3.3*. However, it bears note that condensate would represent a small volume of the constituents of a release (due to the composition of the natural gas reservoir). In the event of a pipeline rupture, the pipeline shut-off valves would be closed automatically, minimising the volume of condensate released to the marine environment. Therefore, the impacts of a condensate release are also anticipated to be NEGLIGIBLE.

Potential Impacts to Marine Fauna – Displacement/Mortality

The pressure of the natural gas released from a blowout or rupture of a pipeline may result in death of fish located in the immediate vicinity, as a result of the pressure released. The underwater noise resulting from a pipeline rupture would likely result in the temporary displacement of fish that occur in the immediate area. However, the vast majority of pelagic marine species will immediately vacate the area and thus will not be significantly impacted by noise. Natural gas rising through the water column is not expected to have a significant impact on marine mammals, as discussed previously.

Impacts associated with a blowout or pipeline rupture are expected to be at a local extent around the release point and of temporary duration, as an emergency shutdown control system will be in operation for the Subsea Production System and pipelines, in accordance with good international industry practice. Impact intensity is anticipated to be Low and the consequence minor. Taking into consideration that the likelihood of a blowout or pipeline rupture/failure occurring is Low, the overall risk significance is MINOR.

Table 14.6 Impact of Blowouts or Pipeline Failure/Rupture on Marine Fauna

Receptor/ Resource	**Marine Ecology**
Extent	Local
Duration	Temporary
Intensity	Low
Consequence	**Minor**
Likelihood	**Low**
Risk significance	**MINOR**

Potential Impacts to Socio-economic Environment

A concern surrounding subsea gas leaks or ruptures to the socio-economic environment is whether or not a natural gas plume resulting from a rupture could result in buoyancy loss of shipping or fishing vessels, to the point where a vessel would sink if it were in the plume. Studies undertaken by Milgram (1984) and Hammett (1985) have shown that the loss in buoyancy of a vessel caused by the rising gas can be overcome by the upward momentum of the plume. The flow of water away from the plume will push vessels away from the bubble zone and vessels will not sink (S.L. Ross Environmental Research Ltd. et al., 2009). The impact of a blowout or pipeline rupture will therefore not impact shipping or fishing vessels should they be located directly above or within close proximity of the damaged subsea infrastructure, and therefore this impact is not assessed further.

14.4.3 Risk Prevention and Response Measures

The objectives of the measures outlined below are to reduce the risk of a blowout or pipeline rupture that could result in the release of hydrocarbons or chemicals into the marine environment.

- BOPs will be installed on the subsea wells, in accordance with good international industry practice, during well drilling and completion operations. BOPs will be inspected prior to installation and tested at regular intervals (determined by a combination of risk assessment, local practice, well type and legal requirements) during operations. Blowout contingency measures will be included in the Project's ERP.

- The Subsea Production System will be developed to good international industry practice, with alarm and shutdown systems to maintain the system within its design criteria at all times. The system will be tested, inspected and maintained to verify integrity and performance standards during construction and operations.

14.5 OTHER IDENTIFIED UNPLANNED EVENTS, RISK CONTROL AND REMEDIATION

As mentioned in *Section 14.1*, rare events including major fires and explosions, storage tank failures or ruptures, flare ignition failures and production shutdowns due to extreme weather conditions could occur during Project operations. These rare events could occur both offshore (ie on the drilling vessel) or at the Project's Near Shore or Onshore facilities.

The Project with input from the FEED Contractors will assess the risks of such unplanned events and associated scenarios as part of a Safety Case / Risk Assessment. The findings of this will inform decisions related to the ultimate design and layout of the Project. The FEED Contractors will comply with any response plans developed (including the ERP in *Annex H*) and develop all other necessary relevant response plans and procedures, which will be approved by the Project. Safety and loss prevention systems incorporated into the Project's design will include a minimum of:

- fire and gas detection and alarm systems;
- fire protection systems;
- emergency communications procedures;
- emergency response procedures and equipment;
- area classification and equipment selection; and
- spill (hydrocarbons and non-hydrocarbons) response plans and equipment.

In addition, support vessels will be provided with fire extinguishing and spill contingency equipment (onshore and offshore), and the operational fleet will include a dedicated response boat.

14.5.1 Risk of LNG Release, Fires and Explosions

This section outlines the risks associated with an LNG spill and fires and explosions respectively. The significance of these unplanned events on the environmental and socio-economic environment are not assessed. However, key management measures, based on good international industry practice (eg the IFC EHS Guidelines for LNG Facilities) to avoid the risk of such scenarios occurring, are detailed below.

LNG is a cryogenic liquid (–162°C) and, when spilled, vaporises into boil-off gas (methane). Under certain conditions, it could result in a vapour cloud if released. Uncontrolled releases of LNG could lead to jet or pool fires if an ignition source is present, or if there is the right concentration of LNG vapour in the air (5 to 15 percent).

The LNG carrier industry claims a record of relative safety over the last 50 years, since international LNG shipping began in 1959. More than 135,000 LNG carrier voyages have taken place without major accidents or safety or security problems, either in port or at sea (The International Group of Liquefied Natural Gas Importers, or GIIGNL, 2011). Similarly, the safety record of onshore LNG terminals is considered good; however, large releases of LNG under specific conditions could pose significant risks.

To minimise the risk of an LNG spill occurring during the transfer of LNG or otherwise, the Project will undertake the following, in accordance with good international industry practice.

- The Project will conduct a Safety Case / Risk Assessment. This will make provision for the identification, assessment, mitigation and management of health and safety hazards and risks associated with the release of LNG, both onshore and within the marine environment.

- The findings of the Safety Case / Risk Assessment will be integrated into the ERP, addressing various scenarios and magnitudes of releases of LNG and proposed spill control response procedures. This should be developed in coordination with the relevant local Mozambican regulatory agencies and to appropriate international standards. The plan should be supported by the necessary resources and training. Spill response equipment should be conveniently available to address all types of spills, including small spills.

- Facilities should be equipped with a system for the early detection of gas releases, designed to identify the existence of a gas release and to help pinpoint its source so that operator-initiated Emergency Shutdowns (ESDs) can be rapidly activated, thereby minimising the inventory of gas releases.

- An Emergency Shutdown and Detection (ESD/D) system should be available to initiate automatic transfer shutdown actions in the case of a significant LNG leak.

- Prepare and implement spill prevention procedures for loading/unloading activities involving marine vessels and terminals, according to applicable international standards and guidelines that specifically address advance communications.

- All LNG storage tanks will be of full-containment design, in accordance with good international industry practice. Full-containment tanks typically feature a primary liquid containment open-top inner tank and a concrete outer tank. The outer tank provides primary vapour containment and secondary liquid containment. In the unlikely event of a leak, the outer tank contains the liquid and provides a controlled release of the vapour.

Fire and explosion hazards at LNG facilities may result from the presence of flammable gases or liquids and ignition sources during loading and unloading activities, and/or leaks and spills of flammable products. Possible ignition sources include sparks associated with the build-up of static electricity, lightning and open flames. As outlined above, the accidental release of LNG may generate the formation of an evaporating liquid pool, potentially resulting in a pool fire and/or the dispersion of a cloud of natural gas resulting from pool evaporation. To minimise the risk of a fire or explosion occurring, the Project will implement the following measures, in accordance with good international industry practice.

- LNG facilities will be designed, constructed and operated according to international standards for the prevention and control of fire and explosion hazards, including provisions for safe distances between tanks in the facility and between the facility and adjacent buildings.

- Safety procedures for the loading and unloading of product to transport systems (eg tanker trucks and vessels) will be implemented, including the use of failsafe control valves and ESD/D equipment.

- A formal fire response plan will be prepared, supported by the necessary resources and training, including training in the use of fire suppression equipment and evacuation. Procedures may include coordination activities with local authorities or neighbouring facilities.

- Measures will be taken to prevent sources of potential ignition such as:

    - proper grounding to avoid static electricity build-up and lightning hazards (including formal procedures for the use and maintenance of grounding connections);

    - use of intrinsically safe electrical installations; and

- implementation of permit to work (PTW) systems and formal procedures for conducting any hot work during maintenance activities, including proper tank cleaning and venting.

- Facilities should be properly equipped with fire detection and suppression equipment that meets internationally recognised technical specifications for the type and amount of flammable and combustible materials stored at the facility.

- All fire systems should be located in accessible areas of the facility, protected from the fire by distance or by fire walls.

- Accommodation areas should be protected by distance or by fire walls. Ventilation air intakes should prevent smoke from entering accommodation areas.

- Fire safety training and response will be provided as part of workforce health and safety induction/training, including training in the use of fire suppression equipment and evacuation, with advanced fire safety training provided to a designated fire-fighting team.

Chapter 15

Cumulative Impacts

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15 CUMULATIVE IMPACTS

15.1 INTRODUCTION

Impacts directly associated with the Project are discussed in the preceding sections. In this section, the potential impacts associated with the cumulative effects of the Project and other developments in the area and region are described. Evaluation of potential cumulative impacts is an integral element of an impact assessment.

Cumulative impacts occur when a Project activity acts together with other activities (other projects or third party activities) to impact on the same environmental or social resource or receptor. The IFC defines cumulative impacts as *'impacts that result from the incremental impact, on areas or resources used or directly impact by the project, from other existing, planned or reasonably defined developments at the time the risks and impacts identification process is conducted'*. Significant cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Past and present activities were considered in developing the environmental and social baseline against which the Project is assessed. For example, the terrestrial ecology baseline takes into account past agricultural practices that have transformed the natural landscape and resulted in an alteration of the habitat for various fauna species. Thus, such previous activities have already been considered in this EIA and used as the baseline to assess the potential impacts of the proposed Project activities. Beyond the past and present activities, the following have been identified as 'reasonably defined' activities that could act together with the Project to cumulatively affect the environment:

- establishment of an Industrial Development Zone (IDZ) by the Government of Mozambique in the vicinity of, or incorporating, the Afungi Project Site; and
- future phases of exploration and development of hydrocarbon resources by AMA1, eni and others.

15.1.1 Limitations and Mitigation

Cumulative effects are difficult to predict as they are the result of complex interactions between multiple projects or activities. This difficulty is compounded by the fact that details of the future development are largely unknown at this stage. Moreover, whether or not a potential future development actually occurs is dependent on a number of factors that are unknown at the time of this assessment. Consequently, cumulative impacts are qualitatively assessed herein, ie high-level descriptions of the potential impact are provided.

Mitigation and management of cumulative impacts often require cooperation with other stakeholders or at a government level, and are frequently beyond the ability of a single project development to control solely. In line with international good practice, mitigation should be commensurate with the level of contribution to the cumulative impact by the developer.

The initial phase of the Project could result in an overall investment of approximately USD25 to 30 billion, making this potentially the largest investment project in Mozambique to date. The Government of Mozambique should see a significant increase in the GDP and through its royalty, tax and equity gas rights. The economic benefits can be compounded several times as the Project expands into future phases. Mozambique is likely to benefit from a substantial increase in Government revenue for the next several decades. This economic benefit could be used to improve the health, education and quality of life of the people of Mozambique.

Given the level of oil and gas development activity in the Rovuma Basin and the sensitivity of the biophysical and social environment, the planning of future hydrocarbon development in the Rovuma Basin would benefit from strategic planning by the Government of Mozambique to fully evaluate the costs and benefits of hydrocarbon development, as well as the other development in the area. It is the intention of the Government of Mozambique to use the natural gas in the Rovuma Basin to encourage industrial development and further expand the social and economic benefits derived from development of Mozambique's offshore natural gas resources. To address the issues associated with the potential future development of Mozambique's hydrocarbon reserves, the Government is developing a Natural Gas Master Plan (1). This Master Plan will address the challenges associated with encouraging the development of hydrocarbon resources (onshore and offshore) in a way that brings the greatest benefit to Mozambique. At present, the Master Plan is in draft form; however, the intent is outlined in below.

(1) The Natural Gas Master Plan for Mozambique Interim Report was submitted to the Government of Mozambique Steering Committee on 8 June 2012, and a Stakeholder Workshop was held in Maputo on 5 and 6 September 2012.

Box 15.1 Draft Vision Statement for the Gas Master Plan

Develop natural gas resources in a manner that maximizes benefits to Mozambique society by supporting --

- *growth in domestic public and private sector institutional competencies;*
- *growth in domestic industry and businesses, especially small and medium scale industries;*
- *increased employment across the country, especially in the less-developed provinces;*
- *infrastructure to support expanded economic activities, especially in less-developed provinces; and*
- *expanded access to training and education*

in order to improve the quality of life for the people of Mozambique, while minimizing adverse social and environmental impacts.

Source: Draft Vision Statement for the Gas Master Plan as presented in the Stakeholder Workshop, held in Maputo on 5 and 6 September 2012.

15.1.2 Potential Resources and Receptors

Specific resources and receptors will vary but, in general, potentially affected resources and receptors could include:

- air quality (through emissions);
- visual and noise;
- surface water;
- groundwater;
- marine ecology;
- terrestrial ecology;
- community health and safety;
- livelihoods and businesses (agriculture, fishing, tourism, employment, etc);
- physical structures and infrastructure (eg homes, roads, etc); and
- sociocultural structures (eg ethnolinguistic groups).

15.2 CUMULATIVE IMPACT OF THE PROPOSED INDUSTRIAL DEVELOPMENT ZONE

15.2.1 Overview

Information currently available related to the location, extent or timing of the establishment of the potential IDZ by the Government of Mozambique is sparse. It is understood that the Government wishes to promote the involvement of domestic investors in megaprojects in the hydrocarbon sector and has established Empresa Naçional de Hidrocarbonetos Logistics (ENHL) to build two ports in Cabo Delgado Province (one in Palma and another in Pemba). It is assumed that the Palma location will be part of the establishment of this IDZ in the vicinity of the Project area, or possibly incorporating the Project area. The IDZ will serve as the area within which future industrial activity (onshore) will be located. The aim, as currently understood, is to consolidate infrastructure and services in one area and to avoid impacts of discreet projects occurring in different areas over a wider area. In addition, during the Maputo public meeting held on 09 September 2013, ENH noted their preference was to have a single LNG park consolidated within the 7,000 ha DUAT area on Afungi peninsula. Other developments within the IDZ may be subject to separate EIA's.

The proposed development of the IDZ could transform a relatively large area from its current rural/agricultural state to facilitate industrial use. Such transformation may result in the alteration of natural watercourses and displacement of native fauna, and may potentially restrict access or otherwise alter the traditional livelihoods of the local communities reliant on the land. These potential impacts are quite similar to those discussed in association with the land acquisition for the proposed LNG Project. However, it is difficult to quantify the extent of the potential impacts at this stage as the scale, timing and other details relating to the IDZ are unknown.

15.2.2 Assessment and Mitigation/Management

Because the specifics of the proposed IDZ and the associated operating scenarios are unknown at this stage, quantifying the potential cumulative impact is not possible. On a qualitative level, it is expected that the IDZ, if managed properly, could have an overall positive impact on both biophysical resources and on socio-economic receptors at the regional level, given that the hydrocarbon resources in this region of the country will undoubtedly be developed. While there may be direct and indirect environmental and social impacts at the local level, in the long term, consolidating this development within the IDZ will ensure impacts are largely concentrated in one area and easier to manage. The IDZ also offers the opportunity for careful thought to be applied to spatial, strategic planning such that potentially conflicting land uses or businesses (eg tourism and industrial development) can be supported in a planned, coordinated fashion, thereby maximising the economic potential of northern Mozambique and minimising negative impacts as far as possible.

Should the IDZ be located adjacent to or incorporating the Afungi Project Site, the Project may share non-proprietary data and information with third parties (such as ENHL and its contractors) to support the impact assessment and consolidated mitigation/management measures that should be used as part of the IDZ planning. Collaboration among local operators in the oil and gas sector and supporting industries, as well as between these sectors and the Government of Mozambique and NGOs, is likely to prove mutually beneficial to all parties operating in the vicinity of Palma District and Cabo Delgado Province.

15.3 CUMULATIVE IMPACT OF FUTURE EXPLORATION AND DEVELOPMENT

15.3.1 Overview

In addition to the proposed Project, several other oil and gas exploration activities are currently underway or scheduled to occur within the vicinity of Offshore Area 1, which may contribute to cumulative effect on the environment.

Exploration activities (seismic and drilling) have recently been carried out for the following oil and gas operators in the vicinity of the offshore Rovuma Basin:

- Onshore Area 1 (AMA1);
- Offshore Area 1 (AMA1);
- Offshore Area 4 (Eni);
- Offshore Areas 2 and 5 (Statoil); and
- Offshore Areas 3 and 6 (PCMRB).

AMA1 completed seismic exploration in Onshore Area 1 in April 2013 and intends to commence exploratory drilling of up to three wells in April 2014.

Eni has drilled several offshore wells and has made significant gas discoveries in Area 4 (adjacent to Area 1). Eni intends to continue this exploration campaign to better characterise the hydrocarbon resources in Area 4 throughout 2014.

Statoil concluded seismic activities in 2011 and submitted EIAs for exploratory drilling in Areas 2 and 5. Statoil drilled two wells, in 2013 and intends to conduct further 3D seismic acquisition in the south of Area 2, as well as drilling of an additional four wells further offshore in Areas 2 and 5.

PCMRB has requested permission to drill a minimum of two wells in Areas 3 and 6, the first one of which was drilled in late 2012. The timing of the operations associated with the drilling of the second well has not been planned.

15.3.2 Assessment and Mitigation/Management

All these projects have the potential to cause positive and negative cumulative impacts. The above potential developments are likely to result in an increase in population, supporting industries and services that would increase pressure on infrastructure and services in northern Mozambique. The positive cumulative impacts would be related to the significant economic development of Cabo Delgado Province and the country. The primary negative cumulative impacts would be the gradual transformation of the relatively undeveloped area with associated impacts on ecological functioning of some ecosystems. From a sociocultural perspective, the positive cumulative impact would be associated with economic development. Other potential cumulative impacts would be changes to the local culture and livelihoods, and this could be perceived as positive or negative.

Specific potential cumulative aspects associated with future exploration and development include:

- community development and economic benefit;
- increased conversion of natural landscape to accommodate the construction of increasing numbers of facilities;
- the current lack of waste, water and electricity infrastructure to support developments;
- the need for skilled labour and training facilities;
- increased shipping and air traffic;
- impacts to the tourism industry; and
- planned and unplanned in-migration of people, with associated impacts on biodiversity, health, crime and levels of intercultural/inter-ethnic conflict.

Enhancement measures will include measures to increase employment, train people and develop supporting infrastructure. Mitigation and management of the negative cumulative impacts depend on effective management strategies to reduce risk to the environmental resources and social receptors, and to offset impacts where mitigation is not possible.

The proposed LNG Project is the first project in what could be a significant development initiative in northern Mozambique by the oil and gas industry. Strategic spatial planning by the Government of Mozambique and its agencies at this early stage is important to ensure development in the region is promoted, while maintaining ecosystem functions and services and social well-being. AMA1 and eni expect to contribute to such planning by

cooperating with Government and other developers in the region, and leading by establishing good management practices.

Chapter 16

Impact Assessment Summary

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16 IMPACT ASSESSMENT SUMMARY

16.1 INTRODUCTION

Through the EIA process a number of positive and negative potential impacts of the Project have been identified and assessed in *Chapters 11- 13* of this EIA Report. This chapter provides a summary of the impacts from planned and unplanned Project activities and is structured as follows:

- *Section 16.2* - Summary of Predicted Impacts from Planned Project Activities
  - Summary of Offshore and Near Shore Environmental Impacts
  - Summary of Onshore Environmental Impacts
  - Summary of Socio-economic Impacts
- *Section 16.3* - Summary of Unplanned Events
- *Section 16.4* - Summary of Cumulative Impacts

16.2 SUMMARY OF PREDICTED IMPACTS FROM PLANNED PROJECT ACTIVITIES

16.2.1 Summary of Offshore and Near Shore Environment Impacts

An overview of potential environmental impacts to the Offshore and Near Shore environment associated with Project activities is provided in *Table 16.1*. The table outlines the pre-mitigation and post-mitigation (or residual) impact significance for each impact assessed in *Chapter 11.*

The sections below provide a summary of the key impacts to the Offshore and Near Shore environment.

Offshore

The drilling of the offshore production wells will be the primary activity likely to result in potential impacts to water quality and marine ecology (such as whales, dolphins and benthos) in the offshore area. With the implementation of mitigation measures, all residual impacts are predicted to be of NEGLIGIBLE and MINOR significance in the offshore marine environment.

Dispersion modelling of the deposition of treated cuttings and the sensitivity of offshore benthic fauna and flora indicates that impacts from physical inundation (burial and change in sediment grain size) will be of MINOR significance before and after mitigation. The deepwater reef structures and associated organisms, however, will be placed at risk of enduring acute effects. The recovery of reef structures is expected to take an appreciable amount of time due to generally slow growth rates of these organisms. Therefore the predicted impact to offshore reef communities may potentially

be of MODERATE significance, although it should be noted that both the high and low-relief structures observed in the deepwaters offshore largely comprise scattered rock and sediment, and do not apparently support high densities of fauna (see *Chapter 7*). With the implementation of mitigation, this will be reduced to MINOR.

Impacts on benthic marine organisms or those in the water column (ie plankton) from discharges of residual drilling muds (WBM and/or SBM) are predicted to be of MINOR significance because of low toxicities of the quantities and types of muds used/or discharged to the offshore environment. Impacts will be reduced to NEGLIGIBLE with the implementation of mitigation.

The impacts on marine ecology and/or marine ecological processes associated with the discharge of hydrotest water at depths of approximately 1,500m in the offshore gas fields during commissioning (ie the construction phase) will be NEGLIGIBLE. Similarly, potential impacts from vessel and helicopter noise, lighting and movements to offshore marine ecology (birds, fish, benthic fauna etc) with the exception of marine mammals will be NEGLIGIBLE. Effects of vessel collisions or disturbance on whales may be more severe due to their conservational importance and the associated impact is predicted to be of MODERATE significance however, mitigation measures outlined in *Chapter 11* specific to whales will ensure that vessel collisions with whales are avoided and thus impact significance is reduced to NEGLIGIBLE.

Changes to the character of the sea bed are likely to result from the addition of hard substrate (subsea infrastructure). This may result in changes to the benthic community structure (ie altered habitat may become colonisation by others organisms) considered to be of MODERATE significance, particularly where deep water reef structures with corals, tunicates and other sessile fauna are affected. Mitigation will result in restricting the residual impact to the apparently vast area of unconsolidated sediments in the offshore gas fields and therefore the impacts will be of NEGLIGIBLE significance during the construction phase.

Near Shore

Within the Near Shore Project Area, where construction activities are focused, there is likely to be disruption of seagrass, coral reefs and some loss of mangrove and estuary areas. These features play critical roles in ecological interrelationships and directly and indirectly support productivity and biodiversity in the Palma Bay area. The implementation of mitigation has helped to reduce the significance of such impacts but the potential remains for bay-scale productivity to be affected.

Pre-mitigation impacts to marine ecology from dredging activities in the Near Shore Project Area have been assessed to be severe, with a number of MAJOR significant impacts being identified. Examples of such impacts include the effects on seagrass, coral and associated biological communities from

increased turbidity in the water column, cutting a trench through coral reef and rock, depositing fine sediment on benthos and modifications to the seabed. The significance of these MAJOR impacts is largely reduced through mitigation. Key mitigation measures include changing the proposed dredging/cutting techniques and avoidance of areas considered particularly sensitive (ie corals along the pipeline route) and measures to reduce turbidity. However, the deposition of fine sediments from dredging activities can inundate seagrass beds and also bury corals or cover them with a veneer of sediment taking considerable time to recover. The re-suspension of sediment and subsequent deposition is unavoidable and subsequent effects to benthos and coral are likely to remain as MAJOR significance post-mitigation.

Dredge material discharged at head of the Afungi Canyon in Palma Bay will smother and possibly result in the death of benthos within the 1km^2 designated placement area. The impact will be of MODERATE significance within dredge placement area itself pre-mitigation, and MINOR post-mitigation. Benthos will however recover within 1-3 years after the cessation of dredging.

The installation of Near Shore infrastructure across the intertidal beaches and extending into the shallow subtidal zone will modify beach structure and dependant ecological processes. This is likely to result in a loss of parts of the productive sand beach and subtidal zones and areas of seagrass meadow. It will allow the establishment of hard substrate communities in the lower intertidal and corals, sponges and associated organisms in the subtidal and may also facilitate colonisation by alien and potentially invasive species. The impacts to the marine biotopes and associated communities within the bay will be MODERATE for the construction and operational phases. With mitigation, including design mitigation, these impacts will be reduced to MINOR significance.

Impacts to fish, whales, dolphins and turtles from noise associated with pile driving in Palma Bay are predicted to be MODERATE significance although the extent of the effects differs among groups. Should a 'soft start' procedure be implemented prior to construction activities when megafauna are present in the bay, the impact will be reduced to MINOR.

If invasive alien species are transferred into Palma Bay via ballast water, effects on biodiversity and marine ecology, including seagrass and corals may be of MODERATE significance. The progressive adoption of developing ballast water control measures and processing techniques as and when sanctioned by IMO will further reduce the likelihood of release of non-indigenous organisms over time. However, due to the high magnitude of the effects that may arise should invasive species become established in northern Mozambique, the significance rating would remain as MODERATE.

Discharges from the proposed desalination and sewage treatment plants as well as from treated produced water and stormwater from the LNG Facility is are likely to have NEGLIGIBLE to MINOR significant impacts on near shore

water quality and marine flora and fauna in Palma Bay prior to mitigation. All impacts from sources of discharge post-mitigation will be NEGLIGIBLE.

The impacts on marine ecology resulting from the loss of the estuary and associated mangrove stand to the east of Afungi Project Site during the construction phase will be of MODERATE significance. The impact will remain as MODERATE significance post-mitigation given the loss of the multi-species mangrove stand.

The establishment of security (exclusion) zones around the LNG Facility and the Near Shore Project infrastructure during construction and operations will displace artisanal fishing effort and locally increase exploitation pressure on the fish community outside of the zones resulting in impacts of MINOR significance. No mitigation measures to help reduce such impacts have been identified.

Discharged solid and liquid wastes from marine vessels during any phase of the Project could potentially result in impacts of MODERATE significance through the proliferation of litter and compromised water quality harming marine organisms, seabirds and biodiversity in Palma Bay. With effective mitigation of waste with appropriate facilities impacts will be reduced to NEGLIGIBLE.

Table 16.1 Summary of Pre-mitigation Impact Significance and Residual Impact Significance for Offshore and Near Shore Environment

Assessment Section	Receptor/ Resource	Impact	Project Phase	Pre-Mitigation Impact Significance	Residual Impact Significance
Section 11.4	Offshore benthos and deep water reef organisms	Impact of Discharge of Drill Cuttings and Residual Muds on Offshore Benthos and Deep Water Reef Organisms	Construction	**MINOR (benthos)** **MODERATE (reef organisms)**	**MINOR (benthos)** **MINOR (reef organisms)**
Section 11.5	Offshore water column, sea bed and marine ecology	Impact of Toxicity Effects on Water Column, Sea Bed and Offshore Marine Ecology from Discharged Drill Cuttings and Residual Muds	Construction	**MINOR**	**NEGLIGIBLE**
Section 11.6	Offshore water column, and marine ecology	Impacts of Discharge of Hydrotest Water on Offshore Water Quality and Marine Ecology	Construction	**NEGLIGIBLE**	**NEGLIGIBLE**
Section 11.7	Offshore marine ecology	Impacts of Increased Noise, Lighting and Vessel Movements on Offshore Marine Ecology	Construction	**NEGLIGIBLE** **(whales MODERATE)**	**NEGLIGIBLE**
			Operational	**NEGLIGIBLE** **(whales MODERATE)**	**NEGLIGIBLE**
Section 11.8	Offshore sea bed	Impacts of Structures Modifying Habitats on the Offshore Sea Bed	Construction	**MODERATE**	**NEGLIGIBLE**
Section 11.9	Near Shore marine ecology	Impacts of Dredging Induced Turbidity on Near Shore Marine Environment (Seagrass, Coral Reef and Associated Biological Communities)	Construction	**MODERATE**	**MINOR**
			Operational	**MINOR**	**MINOR**
Section 11.10	Near Shore marine ecology	Impacts of Turbidity Generated from the Cutting of a Trench Through Coral Reef and rock on Near Shore Marine Ecology	Construction	**MAJOR**	**MINOR**
Section 11.11	Near Shore marine ecology	Impact of Inundation of Sea Bed and Benthos by Depositing Fine Sediments from Dredging Activities on Near Shore Marine Ecology	Construction	**MAJOR**	**MAJOR**
			Operational	**MINOR**	**MINOR**
Section 11.12	Near Shore marine ecology	Impact of Dredging Remobilised Contaminants on Near Shore Marine Ecology	Construction	**NEGLIGIBLE**	**NEGLIGIBLE**
			Operational	**NEGLIGIBLE**	**NEGLIGIBLE**
Section 11.13	Near Shore marine ecology	Impact of Dredging Induced Sea Bed Modification on Near Shore Marine Ecology	Construction	**MAJOR**	**MINOR**
Section 11.14	Near Shore marine ecology	Impact of Disposal of Dredge Material at the Head of Canyon on Near Shore Marine Ecology	Construction	**MODERATE**	**MINOR**

Assessment Section	Receptor/ Resource	Impact	Project Phase	Pre-Mitigation Impact Significance	Residual Impact Significance
Section 11.15	Near Shore marine ecology	Impact of Modification to Sand Beaches Generated by the Presence of Near Shore Project Infrastructure on Marine Communities	Construction	**MODERATE**	**MINOR**
			Operational	**MODERATE**	**MINOR**
Section 11.16	Near Shore marine ecology	Impact of Construction of Artificial Hard Structures on Near Shore Marine Ecology	Construction	**MODERATE**	**MINOR**
			Operational	**MODERATE**	**MINOR**
Section 11.17	Near Shore marine ecology	Impact of Project Generated Noise on Marine Organisms in the Near Shore	Construction	**MODERATE**	**NEGLIGIBLE**
Section 11.18	Near Shore marine ecology	Impact of Ballast Water Discharges from LNG Carriers and the Introduction of Alien Species on Near Shore Marine Ecology	Construction	**MODERATE**	**MODERATE**
			Operational	**MODERATE**	**MODERATE**
Section 11.19	Near Shore marine ecology	Impact Of Discharges from Desalination and Sewage Treatment Plants on Near Shore Water Quality And Marine Ecology	Construction	**NEGLIGIBLE**	**NEGLIGIBLE**
			Operational	**NEGLIGIBLE**	**NEGLIGIBLE**
Section 11.20	Near Shore marine ecology	Impact of the Discharge of Treated Produced Water into the Near Shore on Marine Ecology	Operational	**NEGLIGIBLE**	**NEGLIGIBLE**
Section 11.21	Near Shore marine ecology	The Impact of Episodic Stormwater Discharges from the LNG Facility on Near Shore Marine Ecology	Construction	**MINOR**	**NEGLIGIBLE**
			Operational	**MINOR**	**NEGLIGIBLE**
Section 11.22	Near Shore marine ecology	Impact of Infilling an Estuary on Near Shore Marine Ecology	Construction	**MODERATE**	**MODERATE**
Section 11.23	Near Shore marine ecology	Impact of Security/ Exclusion Zones on Fish Distributions in the Near Shore	Construction	**MINOR**	**MINOR**
			Operational	**MINOR**	**MINOR**
Section 11.24	Near Shore marine ecology	Impact of Ship Operational Discharges on Near Shore Marine Fauna and Seabirds	Construction	**MODERATE**	**NEGLIGIBLE**
			Operational	**MODERATE**	**NEGLIGIBLE**

16.2.2 Summary of Onshore Impacts

An overview of potential bio-physical impacts resulting from Project activities to the Onshore environment is provided in *Table 16.2* below. The table outlines the pre-mitigation and post-mitigation (or residual) impact significance for each impact assessed in *Chapter 12*. The sections below provide a summary of the key impacts to the following:

- Air Quality;
- Greenhouse Gas Emissions/ Climate Change;
- Noise;
- Landscape, Seascape and Visual;
- Soils;
- Groundwater;
- Surface Water Ecology;
- Vegetation;
- Herpetofauna;
- Avifauna; and
- Mammals.

Air Quality

Air dispersion modelling undertaken indicates that during the operational phase of the Two-Train LNG Facility, there will be minimal impacts to human and ecological receptors outside the Afungi Project Site from changes to air quality. Impacts to receptors outside of the Afungi Project Site will be of NEGLIGIBLE significance for all pollutants modelled (NO_2, SO_2, TSP, PM_{10} and $PM_{2.5}$) pre- and post- mitigation with the exception of SO_2 which will be of MINOR significance prior to mitigation and NEGIGIBLE post-mitigation.

However, with the expansion of the LNG Facility to six trains, a potential impact of MODERATE significance may occur from increased levels of SO_2 pre-mitigation. Further consideration of the design of the LNG Facility (in terms of both stack height and turbine technology adopted) is recommended to avoid the potential of exceeding air quality standards during operations of a larger facility.

Greenhouse Gas Emissions/ Climate Change

Assuming Mozambique's GHG emissions will increase by 8 percent per year (based on World Bank GDP growth figures, see *Chapter 12*), emissions from the Project will increase the country's GHG emissions from 0.4 percent per year up to 10 percent per year, depending on the year and period of development (ie construction or operation). The pre-mitigation impact of the Project on Mozambique's national GHG emissions is likely be of MAJOR significance both during the construction and operational phases of the Project. Given the scale and nature of the Project, while good practice can be employed to reduce the GHG emissions, the overall significance of the impact is not expected to significantly change post-mitigation.

Noise

Noise modelling has shown that during normal construction and operational activities noise levels will remain in compliance with Mozambican and IFC noise limits/standards at Noise Sensitive Receptors at night and during the day. Impacts are therefore predicted to be NEGLIGIBLE to MINOR significance pre-mitigation and similar post mitigation.

Landscape, Seascape and Visual

Project activities during the construction phase, including the movement of vessels in and out of Palma Bay and the presence of highly visible equipment and machinery onshore, are likely to have a visual impact of MODERATE to MAJOR significance on Palma Bay Seascape Unit (ie in the coastal area of Palma Bay, see *Chapter 12*). During the operational phase this impact will increase to MAJOR significance, with the introduction and long term presence of the LNG Facility and associated infrastructure on Afungi Peninsula and within Palma Bay. Further south in the Afungi Peninsula to Cabo Nondo Seascape Unit, visual impacts experienced as a result of the Project will be of MINOR significance during construction and MODERATE during operations.

Visual impacts at a number of viewpoint locations considered to be particularly sensitive to change in the wider area are mainly expected to be of MINOR to MODERATE significance during construction. During operations when Project infrastructure is more visible, significance of visual impacts is likely increase to MODERATE to MAJOR, especially in nearby areas such as Palma town, Maganja and within Palma Bay. However, areas further removed from the Afungi Peninsula (Quiwia and the islands of Tecomaji and Rongui) visual impacts are expected to be of MINOR to MODERATE significance during operations. Vamizi Island and Olumbe are expected to have MINOR to NEGLIGIBLE visual impact during operation due to their distance from the Project.

Soils

Impacts to soil and land capability will be predominantly felt during the construction phase during site clearance activities, and will include soil compaction and topsoil loss, water and wind soil erosion and alteration of natural drainage. Impacts of MODERATE significance will be reduced to MINOR with the implementation of appropriate mitigation measures. Spills or leaks of fuel are likely to have NEGLIGIBLE impacts to soil resources as procedures will be put in place to prevent, contain, clean-up and dispose of any spillage as outlined in *Chapter 12*.

Groundwater

Potential impacts to groundwater will be predominantly felt during the early stage of the construction phase when groundwater will be the only source of water. Groundwater abstraction from the production water supply wells may

result in the lowering of groundwater levels (drawdown) in and around abstraction boreholes; however this is deemed to be of low magnitude potentially having a NEGLIGIBLE impact to community wells in the area adjacent to the production water supply wells. Additionally, water abstraction for Project use may have a NEGLIGIBLE impact on environmental receptors reliant on surface water.

Surface Water Ecology

The loss of wetland and estuarine habitat within Catchments A, B, E and small areas of the aquatic wetlands of Catchment C during the construction phase have been assessed as being of MAJOR significance. This significance rating is due to the loss of the ecological functions provided by the wetlands and of important habitat for species of conservational importance. The reconfiguration of the Project layout will result in a much reduced area of wetland and estuarine habitat lost and this coupled with the additional mitigation proposed will reduce impact significance to MODERATE.

With the implementation of mitigation, all other impacts to wetland and estuarine flora and fauna are predicted to be MINOR, reduced from MODERATE in most instances, with the exception of impacts associated with increased turbidity and changes to sediment patterns. Increased turbidity in the wetland and estuaries is mainly likely to occur during the construction phase from onshore activities (eg removal of vegetation, site levelling, infilling of wetlands) and activities in the near shore (eg dredging). A change in sedimentation patterns may affect connectivity of the wetlands, primary production, benthic invertebrates, fish species etc. Impact significance could potentially be MAJOR (1) during this phase of the Project but reduced to MINOR to MODERATE with mitigation.

Vegetation

Much of the existing vegetation within the Afungi Project Site has been altered from its natural state (eg for subsistence agriculture) and fragmented. Site clearance activities during the construction phase are expected to result in further fragmentation and the removal or disturbance of some sensitive vegetation units. Site clearance is expected to result in an impact of MODERATE significance. Given the mitigated Project Footprint layout, the areas of sensitive vegetation units to be lost will be reduced and impact significance is thus reduced to MINOR.

Impacts of MODERATE significance to ecological system functioning may occur from the introduction of undesirable plant species during the construction phase, although with appropriate mitigation outlined in *Chapter 12* such impact will be reduced to NEGLIGIBLE.

(1) Assuming that Catchments A, B and E will be reclaimed based upon the proposed Project Footprint Area, this impact is assessed in terms of Catchments C and D.

Herpetofauna

The impact of site clearance activities, in particular the infilling of wetland areas within the Afungi Project Site will be of MODERATE to MAJOR significance to herpetofauna given the importance of freshwater wetlands in the functionality of their communities. However, the revised Project layout reduces the amount of wetland disturbance and reduces this impact to MINOR significance.

Other impacts to herpetofauna likely to arise during the construction and operational phases of the Project include mortality, disturbance and displacement from the development of access roads and similar linear structures. Changes in water quality of the wetlands within the Afungi Project Site and adjacent areas also present potential impacts of MINOR to MODERATE significance to herpetofauna. These impacts are reduced to NEGLIGIBLE to MINOR post-mitigation as summarised in *Table 16.2*.

The influx of people into the wider area as a result of the Project is expected to put pressure on herpetofauna population density through increased bush fires, killing of herpetofauna individuals, reduced water quality from poor sanitation, subsistence poaching and hunting. Such activities could potentially result in reduced breeding success and depleted local populations and impacts of MAJOR and MODERATE significance during the construction and operational phases respectively. Impacts to areas outside the Project's control are difficult to manage. However with the implementation of proper mitigation, the impact significance will be reduced to MODERATE and MINOR to MODERATE significance.

Avifauna

Areas of important avian sensitivity are largely associated with estuarine salt marshes, freshwater wetlands, large intact forests and the inter-tidal zone and mangrove forests. Five IUCN listed bird species are known to occur within the Afungi Project Site and the loss of such avifaunal habitat is considered MODERATE to MAJOR in significance. However the revision of the Project layout avoids or minimises impact to these sensitive areas. This in conjunction with additional mitigation measures serves to reduce the significance of the impact to MINOR to MODERATE.

Population influx is likely to result in the introduction of domestic animals (livestock and pets) into the area; the introduction of feral animals (dogs and cats) is a likely consequence. Feral animals are likely to prey on avifauna and livestock is likely to reduce habitat quality. As a consequence, avian impacts of MODERATE to MAJOR significance are possible during construction (when workforce is greatest); the impact significance is anticipated to be reducing to MODERATE during operations. With the introduction of mitigation measures, the impact will be reduced to MODERATE and MINOR to MODERATE during the construction and operational phases respectively.

Other impacts to avifauna as assessed in *Chapter 12* are reduced to NEGLIGIBLE to MINOR post-mitigation.

Mammals

Project activities likely to result in impacts of MAJOR significant to mammals are largely associated with site clearance activities. Burrowing mammals, tree dwelling species and smaller mammals are likely to be most affected as they are less able to escape construction equipment or vehicles than larger species. Impacts during the operational phase are likely to be MINOR to MODERATE. However with management through mitigation, impacts are reduced to MINOR significance during both development phases.

The presence of infrastructure including roads, fencing, trenches and pipelines cause loss or fragmentation of mammalian habitat. These may act as deterrents to mammals and have the potential to affect mammalian movements and cause disruption of mammalian migration. Impacts are assessed to be of MODERATE significance during both the construction phase and operational phase of the Project but reduce to MINOR with mitigation.

The most significant potential impacts to mammals remaining following mitigation are the indirect impacts associated with the influx of people into the area. These impacts are likely to be similar to those described for other species above. The various mitigation measures to be implemented by the Project are likely to reduce mammalian impacts to MODERATE during construction and MINOR to MODERATE during operations.

All other impacts to mammals will be reduced to MINOR post-mitigation.

Table 16.2 Summary of Pre-mitigation Impact Significance and Residual Impact Significance for Onshore Environment

Assessment Section	Receptor/ Resource	Impact	Project Phase	Pre-Mitigation Impact Significance	Residual Impact Significance
Section 12.2	Air Quality	Operational Phase Air Quality Impacts to Human Receptors	Operational	**NEGLIGIBLE to MODERATE**	**NEGLIGIBLE**
Section 12.2	Air Quality	Operational Phase Air Quality Impacts to Ecological Receptors	Operational	**NEGLIGIBLE**	**NEGLIGIBLE**
Section 12.3	Greenhouse Gas Emissions/Climate Change	Impact of Project GHG Emissions on Mozambique's National Emissions	Construction	**MAJOR**	**MAJOR**
			Operational	**MAJOR**	**MAJOR**
Section 12.4.2	Noise	Impact of Noise from LNG Processing and Shipping on Off-site Noise Sensitive Receptors	Construction	**NEGLIGIBLE to MINOR**	**NEGLIGIBLE to MINOR**
			Operational	**NEGLIGIBLE to MINOR**	**NEGLIGIBLE to MINOR**
Section 12.4.3	Noise	Impact of Noise from the Airstrip on Off-site Noise Sensitive Receptors	Construction	**MODERATE**	**MINOR**
			Operational	**MINOR**	**NEGLIGIBLE**
Section 12.5.4	Landscape, Seascape and Visual	Impacts of the Project on the Palma Bay Seascape Unit	Construction	-	**MODERATE to MAJOR**
			Operational	-	**MAJOR**
Section 12.5.5	Landscape, Seascape and Visual	Impacts of the Project on the Wooded Inland Landscape Unit	Construction	-	**NEGLIGIBLE**
			Operational	-	**NEGLIGIBLE**
Section 12.5.6	Landscape, Seascape and Visual	Impacts of the Project on the Quionga to Cabo Delgado Seascape Unit	Construction	-	**NEGLIGIBLE**
			Operational	-	**NEGLIGIBLE**
Section 12.5.7	Landscape, Seascape and Visual	Impacts of the Project on the Afungi Peninsula to Cabo Nondo Seascape Unit	Construction	-	**MINOR**
			Operational	-	**MODERATE**
	Landscape, Seascape and Visual	Visual Impact at Selected Viewpoints during Construction	Construction	-	**NEGLIGIBLE to MODERATE**
	Landscape, Seascape and Visual	Visual Impact at Selected Viewpoints during Operations	Operational	-	**NEGLIGIBLE to MAJOR**
Section 12.6.2	Soils	Impact of Site Clearance on Land Capability	Construction	**MODERATE**	**MINOR**
Section 12.6.3	Soils	Impact of Accidental Spills and Leaks of Fuel or Oil on Soil	Construction	**MINOR**	**NEGLIGIBLE**
			Operational	**MINOR**	**NEGLIGIBLE**

Assessment Section	Receptor/ Resource	Impact	Project Phase	Pre-Mitigation Impact Significance	Residual Impact Significance
Section 12.7.2	Groundwater	Impact of Groundwater Abstraction on Community Groundwater Users	Construction	**NEGLIGIBLE**	**NEGLIGIBLE**
Section 12.7.3	Groundwater	Impact of Groundwater Abstraction on Surface Water Ecology Receptors	Construction	**NEGLIGIBLE**	**NEGLIGIBLE**
Section 12.8.2	Surface Water Ecology	Impact of Site Clearance and the Reclamation of Wetlands (Lacustrine and Estuarine) on Wetland Habitat and Ecological Functions provided by these Wetlands	Construction	**MAJOR**	**MODERATE**
Section 12.8.3	Surface Water Ecology	Impact of a Change in Water Quantity and Flow Regime on Wetland Habitat (Lacustrine and Estuarine), Functionality and Aquatic Ecology	Construction	**MODERATE**	**MINOR**
			Operational	**MODERATE**	**MINOR**
Section 12.8.4	Surface Water Ecology	Impact of a Change in Water Quality within the Wetlands (Lacustrine and Estuarine) on Aquatic Ecology	Construction	**MODERATE**	**MINOR**
			Operational	**MINOR to MODERATE**	**MINOR**
Section 12.8.5	Surface Water Ecology	Impact of Increased Turbidity and Change in Sedimentation Patterns on Biological Features of Wetlands (Lacustrine and Estuarine)	Construction	**MAJOR**	**MINOR to MODERATE**
			Operational	**NEGLIGIBLE**	**NEGLIGIBLE**
Section 12.9.2	Vegetation	Impact of Site Clearance on Loss and Fragmentation of Habitats	Construction	**MODERATE**	**MINOR**
Section 12.9.3	Vegetation	Impact of Invasion of Undesirable Plant Species on Ecological System Functions	Construction	**MODERATE**	**NEGLIGIBLE**
			Operational	**NEGLIGIBLE**	**NEGLIGIBLE**
Section 12.10.2	Herpetofauna	Impact of Site Clearance on Sensitive (Areas of High and Medium-High) Herpetofauna Habitat	Construction	**MODERATE to MAJOR**	**MINOR**
Section 12.10.3	Herpetofauna	Impacts of Mortality, Displacement and Disturbance of Herpetofauna Species from Project Activities	Construction	**MODERATE**	**MINOR**
			Operational	**MINOR**	**NEGLIGIBLE**
Section 12.10.4	Herpetofauna	Impact of Water Pollution on Herpetofauna	Construction	**MINOR to MODERATE**	**MINOR**
			Operational	**MINOR to MODERATE**	**MINOR**
Section 12.10.4	Herpetofauna	Indirect Impacts Related to In-Migration of People on Herpetofauna	Construction	**MAJOR**	**MODERATE**

Assessment Section	Receptor/ Resource	Impact	Project Phase	Pre-Mitigation Impact Significance	Residual Impact Significance
			Operational	**MODERATE**	**MINOR to MODERATE**
Section 12.11.2	Avifauna	Impact of Site Clearance Activities on Sensitive (Areas of High and Medium-High) Avian Habitat	Construction	**MODERATE to MAJOR**	**MINOR to MODERATE**
Section 12.11.3	Avifauna	Impact of Project Activities on Sensitive Avian Species through Displacement and Disturbance	Construction	**MODERATE**	**MINOR**
			Operational	**MINOR to MODERATE**	**MINOR**
Section 12.11.4	Avifauna	Disruption of Flyways and Migration Corridors and Off-Site Avian Habitat from Project Activities	Construction	**MINOR**	**NEGLIGIBLE**
Section 12.11.5	Avifauna	Impacts of In-Migration of People on Avifauna	Construction	**MODERATE to MAJOR**	**MODERATE**
			Operational	**MODERATE**	**MINOR to MODERATE**
Section 12.12.2	Mammals	Impact of Habitat Loss on Mammalian Fauna	Construction	**MINOR**	**MINOR**
Section 12.12.3	Mammals	Impact of Site Clearance Activities and Road Traffic on Mammal Species by Direct Mortality and Disturbance	Construction	**MAJOR**	**MINOR**
			Operational	**MINOR to MODERATE**	**MINOR**
Section 12.12.4	Mammals	Impacts of Habitat Fragmentation and Disruption of Natural Migration Patterns on Mammals	Construction	**MODERATE**	**MINOR**
			Operational	**MODERATE**	**MINOR**
Section 12.12.5	Mammals	Indirect Impacts related to In-Migration of People on Mammals	Construction	**MAJOR**	**MODERATE**
			Operational	**MODERATE**	**MINOR to MODERATE**

16.2.3 Summary of Socioeconomic Impacts

An overview of potential impacts to socioeconomic receptors resulting from Project activities is provided in *Table 16.3* below. The table outlines the pre-mitigation and post-mitigation (or residual) impact significance for each impact assessed in *Chapter 13.*

The section below provides a summary of the key impacts to the socioeconomic receptors (ie affected communities, tourism operators, socio-economic infrastructure, community health etc).

Physical and Economic Displacement

The Project expects that everyone residing within the Afungi Project Site will be permanently displaced resulting in loss of dwellings and infrastructure associated with the household, livelihood activities and community assets within the Afungi Project Site. Access to collective natural areas (eg forests, wooded grassland, flood plains/lowlands, dune shrub vegetation, fruit trees, and coconut plantations) will be permanently lost due to the acquisition of land required for the Project. In addition, fishing and sea-based transportation will be affected by Project activities in Palma Bay during the construction and operational phases of the Project due to increased vessel traffic and safety exclusion zones around Project infrastructure. The impacts associated with physical and economic displacement are expected to be of MAJOR significance both during the construction and operational phases. Following the implementation of the Resettlement Action Plan (RAP), the significance will be reduced to impacts of MODERATE significance.

Tourism

The tourism establishments situated on the islands of Tecomaji, Rongui and Queramimbi will be affected by the visual and noise impacts resulting from the construction activities as well as the presence of the Project and vessel traffic during the operational phase. The impact associated with the disruption and loss of attraction of tourism destinations is expected to be of MAJOR significance. This will be reduced to MODERATE with the implementation of mitigation measures including the design of facilities to minimise visual intrusion on the tourism receptors and through appropriate ongoing engagement with tourism operators.

The presence of the Project is likely to a result in MODERATE positive impacts to tourism resorts as a result of increasing demand for accommodation and use of resorts for leisure purposes during both the construction and operational phases.

Project Related In-migration

A wide range of direct and indirect negative environmental, social, and economic impacts to the Project's host communities are associated with Project related in-migration, leading to a potential deterioration in the social context

in which the Project's host communities reside. These impacts are likely to be MAJOR. With appropriate mitigation, including engagement and coordination with relevant authorities impact significance will be reduced to MODERATE.

When properly planned, local communities and businesses may experience positive impacts such as access to improved infrastructure, opportunities for employment, improvement in living standards, increased local skills base and local labour pool as well as the development of new markets.

Community Health

Community health is likely to experience MAJOR significant impacts from the presence of Project workforce, Project related in-migration and diseases brought into the area (such as communicable diseases, vector related diseases and sexually-transmitted infections). Similarly, MAJOR significant impacts to community health may arise indirectly from Project activities or associated with Project related in-migration (such as increased demand on health infrastructure, food and nutrition related issues, accidents and injuries and soil, water and waste related diseases). With the implementation of mitigation measures, most impacts are reduced to MODERATE significance, and some MINOR. During the construction and operational phase, sexually-transmitted infections and high risk sexual practices may remain as MODERATE to MAJOR significance post-mitigation.

Enhancement measures to be implemented will promote community health benefits from the presence of the Project. MODERATE to MAJOR positive impacts on community health are anticipated particularly during the operational phase of the Project.

Economy

The Project will have a range of positive economic impacts at the local, regional, and national levels, including income growth (linked to employment and procurement opportunities), capacity development and increased government revenue. These will range from MINOR positive to MAJOR positive in significance and occur during both the construction and operational phases of the Project. The Project will implement measures to enhance these economic benefits.

There are high expectations associated with the Project including opportunity for employment and procurement of goods and services locally and regionally and general economic development. A potential negative impact is associated with unmet community expectations regarding these aspects and impact significance is expected to be MODERATE during all Project phases, even with the implementation of mitigation measures.

Shipping and Navigation

Impacts to international maritime traffic and national and regional cabotage will range from NEGLIGIBLE to MODERATE significance from the presence of Project vessels and the designation of exclusions zones around Project infrastructure, construction areas and vessels. All impacts will be reduced to NEGLIGIBLE to MINOR once mitigation measures are implemented.

Commercial fishing activities are expected to experience impacts of MINOR to NEGLIGIBLE significance. These potential impacts will be confined to the construction phase of the Project and are most likely to occur in the deep water offshore. Temporary exclusions zones in the offshore gas field and pipeline corridor may impede access to commercial fishing grounds. Impacts are expected to be NEGIGIBLE post-mitigation.

Archaeology

Impacts to onshore archaeology and cultural heritage are expected to be of MODERATE significance during site clearance and construction activities. However impacts will be reduced to MINOR significance with the implementation of the proposed mitigation. During the operational phase impacts will be NEGLIGIBLE.

Impacts to offshore archaeology and cultural heritage are expected to be MINOR during the construction and operational phases prior to mitigation and NEGLIGIBLE following the implementation of the mitigation measures.

Table 16.3 Summary of Pre-mitigation Impact Significance and Residual Impact Significance for Socioeconomic Environment

Assessment Section	Receptor/ Resource	Impact	Project Phase	Pre-Mitigation Impact Significance	Residual Impact Significance
Section 13.2.2	Communities to be physically resettled	Loss of Land and Physical Infrastructure	Construction	**MAJOR**	**MODERATE**
			Operational	**MAJOR**	**MODERATE**
Section 13.2.3	Communities that lose access to natural resources	Loss of Collective Natural Areas (Communal Natural Resources)	Construction	**MAJOR**	**MODERATE**
	Communities that lose access to natural resources	Disruption/Loss of Land-based Subsistence Livelihoods	Construction	**MAJOR**	**MODERATE** **NEGLIGIBLE (salt pans)**
			Operational	**MAJOR**	**MODERATE** **NEGLIGIBLE (salt pans)**
Section 13.2.4	Fishing and sea transportation	Disruption of Marine-Based Economic Livelihoods (excluding Commercial Fishing)	Operational	**MAJOR**	**MODERATE**
			Construction	**MAJOR**	**MODERATE**
Section 13.3.1	Tourist operators	Disruption and Loss of Attraction of Tourism Destinations	Construction	**MAJOR**	**MODERATE**
			Operational	**MAJOR**	**MODERATE**
Section 13.3.2	Tourist operators	Increased Demand for Tourism Facilities (Accommodation and Leisure)	Construction	**MODERATE (+)**	**MODERATE (+)**
			Operational	**MODERATE (+)**	**MODERATE (+)**
Section 13.4.1	Palma District socio-economic infrastructure	Impacts related to PIIM	All Phases	**MAJOR**	**MODERATE**
Section 13.5.1	Community health	Communicable Diseases Linked to Overcrowding and Poor Environmental/ Socio-Economic Conditions	Construction	**MAJOR**	**MINOR**
			Operational	**MAJOR**	**MODERATE**
Section 13.5.2	Community health	Vector Related Diseases	Construction	**MAJOR**	**MODERATE**
			Operational	**MAJOR**	**MODERATE**
Section 13.5.3	Community health	Soil, Water and Waste related Diseases	Construction	**MAJOR**	**MODERATE**
			Operational	**MODERATE**	**MODERATE**
Section 13.5.4	Community health	Sexually-transmitted infections and high risk sexual practices, including HIV/aids	Construction	**MAJOR**	**MODERATE to MAJOR**
			Operational	**MAJOR**	**MODERATE to MAJOR**
Section 13.5.5	Community health	Food and Nutrition-related Issues	Construction	**MAJOR**	**MODERATE**

Assessment Section	Receptor/ Resource	Impact	Project Phase	Pre-Mitigation Impact Significance	Residual Impact Significance
Section 13.5.6	Community health	Accidents / Injuries	Operational	**MAJOR**	**MAJOR (+)**
			Construction	**MAJOR**	**MODERATE**
Section 13.5.7	Community health	Social Determinants of Health	Operational	**MAJOR**	**MODERATE**
			Construction	**MAJOR**	**MODERATE**
Section 13.5.8	Community health	Health Care Services and Infrastructure	Operational	**MAJOR**	**MODERATE (+)**
			Construction	**MAJOR**	**MODERATE**
			Operational	**MAJOR**	**MODERATE to MAJOR (+)**
Section 13.5.9	Community health	Health Programmes and Systems	Construction	**MINOR**	**MINOR**
			Operational	**MINOR**	**MODERATE (+)**
Section 13.6.1	Mozambique economy	Increased Government Revenue	Construction	**MAJOR (+)**	**MAJOR (+)**
			Operational	**MAJOR (+)**	**MAJOR (+)**
Section 13.6.2	Local economy	Employment, Training and Skills Development	Construction	**MODERATE (+)**	**MODERATE (+)**
			Operational	**MODERATE (+)**	**MINOR (+)**
Section 13.6.3	Local economy	Procurement of Local Goods and Services	Construction	**MINOR (+)**	**MODERATE (+)**
			Operational	**MODERATE (+)**	**MODERATE (+)**
Section 13.6.4	Local communities	Unmet Community Expectations for Employment and Procurement Opportunities	Construction	**MODERATE**	**MODERATE**
			Operational	**MODERATE**	**MODERATE**
Section 13.6.5	Local economy	Economic Diversification	Construction	**MODERATE (+)**	**MODERATE (+)**
			Operational	**MODERATE (+)**	**MODERATE (+)**
Section 13.7.1	Maritime traffic	Impact of the Project Vessels and Activity on International Maritime Traffic	Construction	**NEGLIGIBLE**	**NEGLIGIBLE**
			Operational	**MINOR**	**MINOR**
Section 13.7.2	Commercial fishers	Disruption of Commercial Fishing Activities	Construction	**MINOR**	**NEGLIGIBLE**
			Operational	**NEGLIGIBLE**	**NEGLIGIBLE**
Section 13.7.3	Maritime traffic	Impact of the Project Vessels and Activity on National and Regional Cabotage	Construction	**MODERATE**	**MINOR**
			Operational	**MINOR**	**MINOR**
Section 13.8.1	Onshore cultural heritage	Impact of Disturbance of or Damage to Archaeological and Cultural Heritage Sites	Construction	**MODERATE**	**MINOR**
			Operational	**NEGLIGIBLE**	**NEGLIGIBLE**
Section 13.9.1	Offshore cultural heritage	Impact of Offshore and Near Shore Construction and Operational Activities on Marine Archaeology and Cultural Heritage	Construction	**MINOR**	**NEGLIGIBLE**
			Operational	**MINOR**	**NEGLIGIBLE**

16.3 SUMMARY OF UNPLANNED EVENTS

An unplanned event is defined as 'a reasonably foreseeable event that is not planned to occur as part of the Project, but which may conceivably occur as a result of Project activities (eg accidents), even with a low probability. Unplanned events can occur at any phase of the Project onshore and offshore.

The consideration of unplanned events in *Chapter 14* has focused primarily on the risks of:

- large volume spills of chemicals or hydrocarbons; and
- failure of subsea infrastructure (such as well blowout (1) or pipeline failure).

Such events are unlikely to occur, however should large volumes of hydrocarbon spill in the marine environment the potential consequence to biophysical and socioeconomic receptors could be MAJOR. Sensitive habitats (such as corals and mangroves), local communities dependent on fisheries, as well as tourism operators in the vicinity would likely be adversely impacted by such an unplanned event. Impacts associated with the release of large volumes of natural gas in the marine environment (from failure to or damage of subsea infrastructure) will be less significant.

During the FEED process the Project will identify, assess, mitigate and manage health and safety hazards and risks associated with the Project through a Safety Case/ Risk Assessments. The findings of which will inform decisions related to the design and layout of the Project to reduce the likelihood of unplanned events occurring. The representative Emergency Response Plan (ERP) in *Annex H* sets out response and preparedness measures and incorporates an Oil Spill Contingency Plan (OSCP). These measures serve to reduce the likelihood, extent and duration of adverse impacts if an unplanned event occurs.

16.4 SUMMARY OF CUMULATIVE IMPACTS

Vast quantities of natural gas have been discovered in gas fields offshore in the Rovuma Basin. It is likely that a number of Mozambique's offshore natural gas resources will be exploited for gas in the coming years resulting in rapid growth in Cabo Delgado Province as a result of the hydrocarbon industry. The cumulative impacts in the region, both positive and negative, as a result are likely to be significant over the life of the Project and beyond. The following have been considered in *Chapter 15* as 'reasonably defined' future developments that could act together with the Project to cumulatively affect the environment:

(1) A well blowout is an uncontrolled flow of reservoir fluids into the wellbore and sometimes to the surface.

- establishment of an IDZ by the Government of Mozambique in the vicinity of, or incorporating, the Afungi Project Site.

- future phases of exploration and development of hydrocarbon resources by AMA1, eni and others.

Each of these developments alone has the potential to cause positive and negative biophysical and socio-economic impacts. Cumulatively, the developments will result in significant economic development of the Cabo Delgado Province and the country. The primary negative cumulative impacts would result from the gradual transformation of the relatively undeveloped area; impacts associated with ecological functioning of some ecosystems may result.

The establishment of the IDZ may result in direct and indirect environmental and social impacts at the local level, but in the long term, consolidating the Project and other operators within the IDZ will serve to confine impacts to one area and ideally allow for easier management of such impacts. If managed properly, the IDZ could have an overall positive impact on both biophysical resources and on socio-economic receptors at the regional level given that the Mozambican hydrocarbon resources in this region will undoubtedly be developed. Strategic spatial planning by the Government of Mozambique and its agencies at this early stage is important to promote sustainable development in the region.

Chapter 17

Environmental and Social Management System and Environmental and Social Management Plan

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17 ENVIRONMENTAL AND SOCIAL MANAGEMENT SYSTEM AND ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

17.1 INTRODUCTION

This chapter presents the framework for implementation of the Project Environmental and Social Management System (ESMS). The ESMS provides the structure for the management of environmental and social impacts associated with Project delivery. This includes environmental and social monitoring, documenting compliance (eg record-keeping) as required to measure the effectiveness of the mitigation measures, reporting on environmental and social performance, and the process for defining and implementing procedures for corrective action when necessary.

The ESMS framework enables implementation of the Environmental and Social Management Plan (ESMP), which details the actions that will be taken by the Project to mitigate and manage environmental and social impacts based on the activities described in the *Chapter 4:* Project description, *Chapters 6-9*: baseline and *Chapters 10-13:* impact assessment chapters of this EIA. Implementation of the ESMP provides tools for auditing the Project's mitigation and monitoring activities, and communicating monitoring outcomes to stakeholders (1).

The ESMS is supported by the following annexes:

- *Annex C*: Specialist Methodologies
  Annex C provides a description of the methodologies developed and used by the various environmental and socio-economic specialists contributing to this EIA to collect, interpret and present baseline findings for their respective specialist studies.

- *Annex D*: ESMP Tables
  Annex D tabulates the Project impacts, associated management and/or mitigation measures as described in this EIA, and summarises key monitoring requirements and responsibilities for implementation.

- *Annex E*: Waste Management Plan
  Annex E is the Project Waste Management Plan (WMP), developed to facilitate evaluation and assessment of the Project impacts associated with the generation of waste. The WMP also outlines how waste generated as a result of the Project will be managed in accordance with Mozambican laws and regulations, recognised international good practice and the Project's general environmental and waste management policies.

(1) A Stakeholder Engagement Plan is being developed by the Project to describe its engagement strategies with identified project stakeholders.

- *Annex F*: Decommissioning and Rehabilitation Plan
  The Project's Decommissioning and Rehabilitation Plan (DRP) provides a framework, including a set of guidelines and actions, for facilitating decommissioning and rehabilitation activities. The DRP will need to be updated and submitted to MICOA for approval two years before Project closure.

- *Annex H*: Emergency Response Plan
  Annex H provides a representative Emergency Response Plan (ERP) which defines an organizational structure and provides a framework for responding to an emergency situation.

- *Annex* I: Initial Resettlement Plan
  The Project's Initial Resettlement Plan (IRP) contains the approach, principles and procedures which will be followed in resettlement planning. The IRP provides a framework for the future development of a Resettlement Action Plan (RAP).

The remainder of this chapter is structured as follows:

- *Section 17.2:* Environmental and Social Management System Overview; and

- *Section 17.3:* Framework for Implementation of the Environmental and Social Management Plan:
  - Introduction;
  - Organisation, Roles and Responsibilities;
  - Training, Education and Competency;
  - Assessment and Improvement;
  - Incident Management;
  - Grievance Management;
  - Reporting, and
  - Managing Changes.

17.2 ENVIRONMENTAL AND SOCIAL MANAGEMENT SYSTEM OVERVIEW

IFC Performance Standard 1 requires that an ESMS be developed to support an organisation's overall management systems to address environmental and social impact management effectively. The overarching management system is the Project's Management System that:

- enables the Project to manage activities in a healthy, safe and environmentally and socially responsible manner;

- establishes a common set of objectives and expectations;

- provides a structure to organise processes, programmes and procedures that enable the Project to carry out these objectives and expectations;

- is designed to identify, evaluate and control Project risks in a way that prevents or mitigates incidents that could impact people, the environment or assets; and

- applies to the entire asset life cycle: starting with design or acquisition, continuing through construction, installation, start-up and operations, and on through abandonment or divestiture.

The ESMS is developed in the context of the Project's Project Management System. The key steps or processes of the ESMS are illustrated in *Figure 17.1,* and each of the steps are further detailed below.

Figure 17.1 ***Environmental and Social Management System Implementation Process***

17.2.1 Plan

The planning processes of the ESMS includes the following activities and considerations:

- defining the Project's policies, objectives and requirements for environmental and social performance;

- identifying environmental and social impacts and risks of the operations;

- developing mitigations and operational controls to address impacts and risks; and

- developing the management plans to achieve these objectives (that collectively produce the ESMP).

17.2.2 Implement

Implementation of the ESMS through the ESMP identified above will involve:

- implementing various environmental and social management plan(s); and
- implementing mitigation and management controls.

17.2.3 Assess

The assessment of the ESMS includes:

- assessing and evaluating performance against policies and objectives; and
- checking that mitigations and management controls are effective.

17.2.4 Improve

Improving ESMS performance involves:

- making corrections to plans, mitigations or controls in response to performance monitoring.

17.3 FRAMEWORK FOR IMPLEMENTATION OF THE ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

17.3.1 Introduction

For the ESMP to be effectively implemented, the following areas need to be addressed by the ESMS:

- organisation, roles and responsibilities;
- training, education and competency;
- assessment and improvement;
- grievance management;
- incident management;
- reporting; and
- managing changes.

Each of these implementation elements is described in detail below.

17.3.2 Organisation, Roles and Responsibilities

The Project is ultimately accountable for the management and supervision of all Project activities. This responsibility includes the management of all contractors to ensure they contribute to helping the Project achieve its environmental and social performance objectives. Clear roles will be defined between the Project and contractors to determine leadership and responsibility for contributing to meeting environmental and social

performance expectations, and will entail at least the broad roles and responsibilities outlined in *Table 17.1* below.

Table 17.1 Key Project Roles and Responsibilities

Role	Responsibility
Management	• Manage implementation of the ESMS: plan, implement, assess and improve. • Oversee and monitor implementation of the ESMP for the Project. • Provide strategic environmental and social direction to the Project.
Supervision	• Work with contractors to achieve environmental and social performance by undertaking the following: o conduct readiness reviews with contractors to ensure their ESMS implementation meets Project requirements; o work with contractors to improve their ESMS where gaps are identified; o conduct training and awareness programmes with personnel involved in ESMP implementation; o ensure regular monitoring and evaluation of the Project's performance against the ESMP; o maintain records of all non-conformances and work with the relevant parties to resolve within reasonable time frames; o assess the efficacy of the mitigation measures and manage continuous improvement around these measures; o collate all required Project environmental and social reports and ensure they meet Project reporting requirements; o provide day-to-day advice and counselling on all Project environmental and social requirements; o work with contractors to close out grievances lodged by communities within the defined timelines; o maintain accurate records of open and closed grievances, and work with contractors towards reducing the number of grievances lodged by implementing appropriate mitigation measures; and o assist with the development of relevant and timely communications to Project-impacted communities by providing information to the Stakeholder Engagement team on upcoming Project activities.
Delivery/Implementation	• Monitor and report on any Project activities that could negatively impact on communities. • Facilitate ongoing, reciprocal information sharing and communication between the Project and impacted communities; including helping to resolve any Project-related issues raised. • Support the Project's grievance procedure by providing ongoing grievance procedure guidance and training to Project personnel, contractors and impacted communities and other relevant stakeholder groups (eg tourism industry stakeholders). • Conduct regular inspections and note non-conformances with the Project's environmental and social requirements.

17.3.3 Training, Education and Competency

The Project assumes overarching responsibility for implementation of the ESMP and, as such, it is important that all contractors and personnel responsible for the implementation of the tasks and requirements contained in the ESMP are competent on the basis of education, training and experience. The Project will undertake internal training and education activities to ensure that Project expectations regarding environmental and social performance are achieved. In addition, the Project will provide guidance to contractors regarding expectations for environmental and social impact management training, education and competencies. Environmental and social competencies will be appropriate to the respective parties' scope of activity and level of responsibility. Project will undertake an initial evaluation of training needs associated with this ESMP and, on this basis, develop and maintain an ESMP training matrix.

The Project's environmental and social training programmes will include several levels of competency, depending on each individual's level of involvement and responsibility:

- **ESMP Induction Training and Awareness**: this training will be for visitors or individuals who do not have direct roles or responsibilities for implementing the ESMP, and will cover basic Project environmental and social commitments.

- **ESMP Management Training and Awareness**: this training focuses attention on management, covering key aspects of the ESMP and providing an overview of the Project's environmental and social impact management expectations and the supporting processes and procedures prescribed in the ESMS to meet performance expectations.

- **ESMP Job-specific Training and Awareness**: job-specific training will be provided to all personnel who have direct roles and responsibilities for implementing or managing components of the ESMP. This training will also include all people whose specific work activities may have an environmental or social impact.

Onsite, these provisions and responsibilities will apply to all contractors and subcontractors. Those responsible for performing site inspections will receive training by drawing on external resources as necessary. Upon completion of training and once deemed competent by management, staff will be ready to train other people. The Project will require each contractor to institute training programmes for their personnel. All contractors and their subcontractors will be responsible for implementing relevant and adequate training programmes to maintain the required competency levels. Contractor training programmes will be subject to approval by Project Management and will be assessed to confirm that:

- training programmes are adequate;

- all relevant personnel have been trained; and
- competency is achieved.

Contractors will be required to report on their training activities, and the Project will maintain records of all training delivered.

17.3.4 Assessment and Improvement

This section outlines the assessment and improvement processes associated with this ESMP: inspection, monitoring, audit, corrective action and improvement. These activities form an integral part of implementing the ESMP, and are necessary to:

- verify and document the management and implementation of the mitigation measures identified in the ESMP;
- monitor and document the effectiveness of the mitigation measures and assess the actual impacts;
- demonstrate compliance with applicable legal and other requirements;
- evaluate the effectiveness of the ESMS; and
- highlight areas in need of improvement to drive continuous improvement for all ESMP activities.

Inspection

Contractors will be required to implement field-based inspection programmes that demonstrate their implementation of – and, in some instances, the effectiveness of – the mitigation measures. The Project will, in turn, inspect the contractors' documents to verify that they have implemented the required programmes.

Monitoring

Contractors will be required to implement field-based environmental monitoring (sampling and analysis) and social monitoring to monitor the effectiveness of the mitigation measures, assess impacts and demonstrate compliance with legal and other requirements. The Project will conduct similar monitoring events and also verify contractors' monitoring activities.

Auditing

Audits will be carried out internally by the Project to ensure compliance with ESMP requirements, regulatory requirements and compliance with management systems, standards, policies and procedures. Periodic third party audits may also be required by the Project or lender groups, as agreed to by the parties. Audits will be performed by qualified staff, and results will be

described in a report that will determine the severity of non-compliances, as well as the recommended remedial action.

Corrective Action and Improvement

As part of the ESMS, the Project will implement a formal environmental and social tracking system that will include the details of all environmental and social non-conformances, identify the corrective actions required, assign actions/timings to responsible parties and indicate the status of the actions required. This will ensure a coordinated approach between the Project and its contractors, and drive changes for continuous improvement.

17.3.5 Grievance Management

The Project will develop and implement a Grievance Procedure that is described in the Project's Stakeholder Engagement Plan (SEP). The Grievance Procedure describes how community members can raise grievances regarding the Project's activities. The Grievance Procedure addresses verbal or written grievances, which must include sufficient information about the complaint or claim so that a proper and informed evaluation of the grievance can be made. When a grievance is filed, it will be logged and evaluated using the process outlined in the SEP. All grievances will be tracked for monitoring and reporting purposes and to ensure timely and proper resolution.

17.3.6 Incident Management

An incident is described as a specific event, sequence of events, or extended condition that has an unwanted or unintended impact on safety, security, health, livelihood, property, environment or regulatory compliance.

The Project will develop an incident management process that will describe the Project's requirements for managing safety, health, environment, social and security-related incidents, including near-misses. The underpinning principles will be to:

- avoid and reduce harm to communities, personnel, environment and assets;
- confirm proper remedial action and perform appropriate follow-up surveillance to ensure injuries, damage or illnesses do not escalate;
- communicate incident details to internal and external stakeholders as appropriate; and
- investigate all incidents to identify root causes and implement corrective actions to prevent incident recurrence and drive continuous improvement.

The incident management system will involve the following, which may occur concurrently during implementation:

- securing the area;
- initiating emergency response procedures if required;
- performing case management for injuries or illness;
- incident classification, notification and investigation;
- implementing corrective actions;
- relevant reporting; and
- lessons learned.

All incidents will be tracked in a Project tracking system.

17.3.7 Reporting

This section outlines the reporting and notification associated with implementation of the ESMP. The Project and contractors will work closely together to identify and agree all such Project notification and reporting requirements. It is envisaged that reporting will cover at least the following areas:

Contractor Monthly Reporting

Contractors will work closely with the Project prior to the commencement of work to define the structure, content and format for their environmental and social monthly report. This report will contain key information around the contractors' implementation of the environmental and social requirements and mitigation measures and will cover, among others:

- environmental and social assessment and improvement findings;
- incident notifications;
- non-conformances/non-compliances and corrective actions;
- key performance indicators;
- details of any environmental or social surveys or studies; and
- environmental and social training conducted.

Quarterly Reporting

The Project will prepare and submit to the relevant government departments a Project Environmental and Social Quarterly Report. The structure, content and format will be agreed with government prior to the commencement of work. This quarterly report will document key information on the Project's performance against the ESMP requirements.

Incident Notification and Reporting

Contractors will notify the Project immediately following any environmental or social incident. Project will ensure that all environmental and social incidents are appropriately documented, that the relevant parties are notified, and that reporting requirements around the incident are met.

Statutory Notifications and Reporting

The Project and contractors will meet all statutory notification and reporting requirements.

17.3.8 Managing Changes

Changes in the Project may occur due to unanticipated Project developments. This EIA, for example, is being undertaken prior to the completion of the FEED stage of the Project. Wherever possible, the environmental and social mitigation measures that have the potential to impact design have been passed to the relevant FEED contractors during the EIA process. As the EIA progressed, certainty regarding the nature and magnitude of impact sources became clearer to the Project and the relevant changes were made to the EIA Report. Adaptive changes may also occur during Project commissioning and operations.

The Project will implement a formal procedure to manage changes that will apply to all Project activities. The process for dealing with Project changes and uncertainty recognises three levels of change/uncertainty:

- **Level One: Minor Significance,** where the change or uncertainty is largely deemed to be immaterial to the EIA findings, and does not affect the Project's ability to meet environmental and social performance requirements outlined in the ESMP. This change may require additional but limited environmental or social study or survey activities.

- **Level Two: Moderate Significance,** where the change or uncertainty is deemed to be material to the EIA findings, but is within the boundaries of the defined Project base-case covered by the EIA. This may require minor changes to the ESMP and additional surveys or environmental and social assessments.

- **Level Three: Higher Significance,** where a future significant change or uncertainty leads to a departure from the base-case, or a key aspect of it. An addendum to the EIA, or a new EIA and formal submission and approval process, is then required.

The abovementioned process will ensure that the Project is able to adapt to changes whilst meeting the relevant environmental and social performance requirements.

17.4 COMMUNICATION TO STAKEHOLDERS

As noted during the EIA public meetings held in September 2013, the Project is committed to engaging with and reporting to all stakeholders. As part of the project financing, an independent environmental and social consultant is

anticipated to be hired by the project lenders. Their auditing reports will be shared with stakeholders in a transparent manner, as they become available.

Chapter 18

Conclusion

CONTENTS

18 CONCLUSION 18-1

In accordance with Mozambican legislation, the EIA process for this Project has complied with the Environmental Law (Law no. 20/97 of 1 October), the Environmental Impact Assessment Regulations (Decree no. 45/2004 of 29 September and Decree no. 42/2008 of 4 November, which amends some articles of Decree no. 45/2004) as well as Environmental Regulations for Petroleum Operations (Decree no. 56/2010 of 22 November).

The aim of the EIA process is to provide information for decision-making to contribute to sustainable development. The overall EIA process has comprised of a number of key steps undertaken in a systematic manner over a period of two and a half years, namely:

- Site selection.
- Scoping.
- Baseline data collection.
- Impact assessment and development of mitigation measures.
- Consultation with stakeholders.

Site selection occurred early on in the process and provided the point of departure for the EIA. The Afungi Project Site was determined to be the preferred site from an integrated environmental, social, and technical perspective.

Scoping entailed identifying the Project's potential impacts, adding input to the Project design, and describing the Terms of Reference for the Impact Assessment Phase and for the specialist studies in particular.

The EIA Team has drawn on both publically available and field-collected data to describe baseline conditions in the study area. The baseline description covers a spectrum of social, environmental and physical aspects. Thereafter the team identified and independently evaluated the potential environmental and socio-economic impacts that may result from the development of the Project. The EIA process has assisted the Project to identify a wide range of specific mitigation measures that will be implemented to avoid or reduce negative impacts and to enhance the potential benefits (positive impacts) that the Project can bring to the Palma District, Cabo Delgado Province and Mozambique.

Project refinements and mitigation measures were developed during the Site Selection process (early to mid-2011), the EPDA Phase (later part of 2011) and through the course of the Impact Assessment Phase (2012-2013). Mitigation measures were developed during a number of integration and mitigation workshops that were held between the EIA Team and the Engineering Team through the course of the impact assessment process. This collaboration helped to further align the needs of the Project with the environmental and

social sensitivities of the area and helped to identify avoidance and mitigation measures suitable to reduce the risk of adverse impacts.

The mitigation measures were incorporated into project design as embedded controls or are part of the ESMP and are Project commitments which will be used to develop a series of construction or operational management plans. *Chapter 16* summarises the identified impacts, pre- and post-mitigation. *Chapter 17* and *Annex D* together comprise the Project's commitments to environmental and socio-economic management.

Consultation with stakeholders (general public, local community members, tourist operators, environmental NGOs and authorities) occurred during the EPDA Phase and Impact Assessment Phase. A Public Participation Report (*Annex A*) describes the consultation process followed and has a table that details comments received and responses by the EIA Team and Project. At a high level, key issues raised to date by stakeholders relate to:

- Land acquisition (process followed and communication).
- Displacement (physical and economic).
- Job creation and training for local communities.
- Economic benefits and community development.
- Impacts on livelihoods (tourism, fishing and agriculture).
- Impacts on biodiversity and ecosystems (marine and terrestrial).
- Impacts on health, safety and security.
- Implementation of mitigation and management measures (effectiveness of mitigation or capacity of authorities to monitor).

The investigation of the issues raised by stakeholders, as well as the range of issues identified by the EIA Team, did not reveal any fatal flaws that could prevent the Project from going ahead. The primary reason for this is the close interaction between the Engineering Team and the EIA Team which resulted in numerous mitigation measures being incorporated into the Project design during Pre-FEED and the early stages of FEED. As FEED is yet to be completed, it is important to note that should the project description change significantly from that described herein, such that new significant impacts would be generated or the identified mitigation measures no longer apply, the Project will liaise with MICOA to identify the appropriate means of addressing the change; this could be an additional EIA process or an addendum to this EIA Report and any associated public consultation.

Chapter 19

References

CONTENTS

19 REFERENCES 19-1

Adamowicz, L. and Nhatule, E. 2012. *Archaeological Impact Assessment for the proposed Liquefied Natural Gas Project in Afungi and Cabo Delgado Peninsular, Palma District Cabo Delgado Province.* Cultural Heritage and Archaeology Field Study 20 – 30 OCTOBER 2011. Prepared for Impacto.

Administração Nacional de Pescas (ADNAP) (National Fisheries Administration), 2013. Plano de Desenvolvimento da Pescaria de Atum (*PEDPA) - Strategic Plan for the Development of Tuna Fisheries in Mozambique).* Maputo, Mozambique.

Agreco, 2008. *National Census of Wildlife*. Ministério da Agricultura, Maputo.

Allanson, B.R. and Baird, D. 1999. *Estuaries of Southern Africa*. 340 pp. Cambridge University Press, Cambridge.

AMA1, 2012. *Assessment of Sediment Transport and Shoreline Change Potential – Mozambique Field Development.* Document EA-MZ-FA0000-MON-U05-00008-00, prepared for Anadarko by Moffat & Nichol, June 2012.

AMA1, 2012. *Mozambique Fact Sheet 2012*. [online] Available at: <http://www.anadarko.com/SiteCollectionDocuments/PDF/Fact%20Sheets/2012_APC_MozambiqueFactSheet.pdf> [Accessed 16 April 2013].

AMEC, 2011. *Hydrogeological Conditions Desk Top Study, LNG Siting in Northern Coastal Mozambique*.

AmphibiaWeb, 2012. *Information on Amphibian Biology and Conservation*. [online] Available at: <http://amphibiaweb.org/> [Accessed 20 April 2012].

Anadarko, 2012. *Projects Produced Water Quality – from Samples Drawn from an Average Depth of 2750 m below the Seabed. in litt.*

Anadarko Moçambique, N.D. *Air Emissions, Liquid Effluents and Solid Wastes – Construction Phase*. Document EV-AAA-EV1-0003 (adjusted to account for increased workforce and including Near Shore Project contribution).

Anderson, J.L. and Pariela, F. 2005. *Strategies to Mitigate Human-Wildlife Conflicts Mozambique*. Wildlife Management Working Paper No. 8. Food and Agriculture Organization of the United Nations, Rome.

ANZECC, 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australia and New Zealand Environment and Conservation Council.

Augusto, G., Nala R, Casmo V, Sabonete A, Mapaco L, Monteiro J., 2009. *Geographical Distribution and Prevalence of Schistosomiasis and Soil-Transmitted Helminths among Schoolchildren in Mozambique.* American Journal of Tropical Medicine and Hygiene, Forthcoming 2009.

Austral COWI, 2012. *Rapid Health Impact Assessment*. Anadarko Mocambique Area 1 Limitada, AMA1 LNG Project.

Awad, A., Clarke, C., Greyling, L., Hilliard, R., Polglaze, J. and Raaymakers, S. 2004. *Ballast Water Risk Assessment, Port of Saldanha Bay, Republic of South Africa, November 2003: Final Report.* GloBallast Monograph Series No. 13. IMO, London.

Bagnold, R.A. 1937**.** The transport of sand by wind. *The Geographical Journal*. **89(5)** 409-438**.**

Baker, N.E. and Baker, L.M. 2001. Tanzania. In: Fishpool, L.D.C. and Evans, M.I. (eds) *Important Bird Areas in Africa and Associated Islands: Priority Sites for Conservation.* BirdLife Conservation Series No. 11, pp. 897-945. Pisces Publications and BirdLife International, Newbury and Cambridge, UK.

Bank of Mozambique, 2009. *State Budget Execution Report Year 2009 January to December.* Bank of Mozambique, Maputo.

Bank of Mozambique, 2010. *State Budget Execution Report Year 2010 January to December.* Bank of Mozambique, Maputo.

Bank of Mozambique, 2011. *State Budget Execution Report Year 2011 January to December.* Bank of Mozambique, Maputo.

Barnes, K.N. 2000. *The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland*. BirdLife South Africa, Johannesburg.

Bennet, N., 1987. *Zanzibar, Portugal and Mozambique: Relations from the late eighteenth Century to 1890.* Working Papers in African Studies, No. 123, African Studies Center - Boston University, Boston.

Berglund, B., Lindvall, T. and Schwela, D.H. (eds) 1999. *Guidelines for Community Noise.* World Health Organization. [online] Available at: <http://whqlibdoc.who.int/hq/1999/a68672.pdf> [Accessed 15 April 2013].

Best, P.B. 2007. *Whales and Dolphins of the Southern African Subregion.* 338 pp. Cambridge University Press, Cape Town.

Bills, I.R. 2001. *An Inventory of Fishes from the Maputo Special Reserve and Futi Corridor, Mozambique, 21/9/2001 to 6/10/2001.* Investigational Report No. 63. JLB Smith Institute of Ichthyology, Grahamstown.

Bills, I.R. 2004. *A Survey of the Fishes in the Niassa Reserve, Niassa and Cabo Delgado Provinces, Mozambique, 10-30/8/2003*. SAIAB Investigational Report 69.

Branch, W.R. 1998. *Field Guide to Snakes and Other Reptiles of Southern Africa.* Struik, Cape Town.

Brooks, A., Chessman, B. and Haeusler, T. 2010. *Assessing the Ecological Impact of Water Abstraction on Macroinvertebrates in Unregulated Rivers – Reference Site Selection.* NSW Office of Water, Sydney.

Calmano, W., Hong, J. and Forstner, U. 1993. Binding and mobilisation of heavy metals in contaminated sediments affected by pH and redox potential. *Water Science and Technology.* **28** 223–235.

Carlton, J.T. and Geller, J.B. 1993. Ecological roulette: the global transport of nonindigenous marine organisms. *Science.* **261** 78–82.

Center for Liquefied Natural Gas (CLNG), 2011. *Safety/Security*. [online] Available at: <http://www.lngfacts.org/about-lng/safetysecurity/> [Accessed 17 January 2013].

Channing, A. 2001. *Amphibians of Central and Southern Africa*. Protea Bookhouse, Pretoria.

Cohen, C., Spottiswoode, C. and Rossouw, J. 2006. *Southern African Birdfinder: Where to Find 1 400 Bird Species in Southern Africa and Madagascar*. Struik, Cape Town.

Cooley, H., Gleick, P.H. and Wolff, G. 2006. *Desalination, with a Grain of Salt: A California Perspective*. The Pacific Institution. [online] Available at: <http://www.pacinst.org/reports/desalination/desalination_report.pdf> [Accessed 15 April 2013].

CORIS, 2012. *NOAA's Coral Reef Information System*. [online] Available at: <http://coris.noaa.gov/about/deep> [Accessed 15 April 2013].

Council for Scientific and Industrial Research (CSIR), 2006. *Sediment Heavy Metal Median Concentrations (mg/kg) Data for Near Shore Study Area in Palma Bay.* CSIR, Pretoria.

Crecelius, E., Trefry, J., McKinley, J., Lasorsa, B. and Trocine, R. 2007. *Study of Barite Solubility and the Release of Trace Components to the Marine Environment.* 147 pp. OCS Study MMS 2007 061. US Department of the Interior, Mineral Management Service, Gulf of Mexico OCS Office, New Orleans, LA.

CSA, 2007. *Representative Marine Habitat Survey in Quirimbas Archipelago, Moçambique*. Survey prepared for Anadarko Moçambique Área 1, Lda. 20 pp.

CSA, 2008. *Representative Marine Habitat Survey in Quirimbas Archipelago, Moçambique.* 25 pp. Final report for Anadarko Moçambique Area 1, Lda., July 2007.

CSA International, Inc., 2012. *Characterization of Deepwater Seafloor Habitats and an Assessment of Potential Effects of Drilling Discharges at Five Wellsite Locations Offshore Mozambique*. Prepared for Anadarko Area 1 Lda., August 2012.

CSIRO, 2005. *Analysis of Hydrostatic Test Water*. 100 pp. Final Report for APIA. CSIRO Manufacturing and Infrastructure Technology (CMIT) Report No. CMIT–2005–259.

Cyrus, D.P., Wepener, V., Mackay, C.F., Cilliers, P.M., Weerts, S.P. and Viljoen, A. 2000. *The Effects of Interbasin Transfer on the Hydrochemistry, Benthic Invertebrates and Ichthyofauna of the Mhlathuze Estuary and Lake Nsezi*. WRC Report No. 722/1/00. Water Research Commission, Pretoria.

Dallas, H.F. and Day, J.A. 2004. *The Effect of Water Quality Variables on Aquatic Ecosystems: A Review.* WRC Report No. TT 224/04. Water Research Commission, Pretoria.

Department of Agricultural Development, Soil Classification Working Group, 1991. *Soil Classification. A Taxonomic System for South Africa*. Memoirs on the Agricultural Natural Resources of South Africa No. 15. Institute for Soil, Climate and Water, Pretoria.

Department of Water Affairs (DWA), 2010. *Resource Directed Measures for Protection of Water Resources: Methods for the Determination of the Ecological Reserve for Estuaries.* Water Resource Protection and Assessment Policy Implementation Process, Version 3. DWA, Pretoria.

Department of Water Affairs and Forestry (DWAF), 1996a. *South African Water Quality Guidelines, Volume 7: Aquatic Ecosystems.* DWAF, Pretoria.

Department of Water Affairs and Forestry (DWAF), 1996b. *South African Water Quality Guidelines, Volume 8: Field Guide.* DWAF, Pretoria.

Department of Water Affairs and Forestry (DWAF), 1996c. *South African Water Quality Guidelines for Coastal Marine Waters, Volume 1: Natural Environment*, 1st edition. DWAF, Pretoria.

Department of Water Affairs and Forestry (DWAF), 2003. *A Practical Field Procedure for the Identification and delineation of Wetlands and Riparian Areas.* DWAF, Pretoria.

De Ruijter, W.P.M., Ridderinkhof, H., Lutjeharms, J.R.E., Schouten, M.W. and Veth, C. 2002. Observations of the flow in the Mozambique Channel. *Geophysical Research Letters* **29(10)** 140-1–140-3, DOI: 10.1029/2001GL013714.

DHI, 2011a. MIKE C-MAP, *Extraction of World Wide Bathymetry Data and Tidal Information, User Guide*. Danish Hydraulics Software.

DHI, 2011b. MIKE 21, *Flow Model, Hydrodynamic Module, User Guide*. Danish Hydraulics Software.

Digby Wells (Environmental), 2012. *Soil Specialist Study as Part of an Environment Impact Assessment for the Development of a LNG Facility on the Afungi Peninsula near Palma, Northern Mozambique*.

Di Marco, S.F., Chapman, P., Nowlin, W.P. Jr., Hacker, P., Donohue, K., Luther, M., Johnson, G.C. and Toole, J. 2002. Volume transport and property distributions of the Mozambique Channel. *Deep-Sea Research II* **49** 1481–1511.

Discovery of Sound in the Sea, N.D. *Sounds in the Sea.* [online] Available at: <http://www.dosits.org/science/soundsinthesea/commonsounds/> [Accessed 15 April 2013].

Doorn-Groen, S.M. 2007. Environmental monitoring and management of reclamations works close to sensitive habitats 3. *Terra et Aqua* **108** 2–18.

Draft Vision Statement for the Gas Master Plan as presented in the Stakeholder Workshop, held in Maputo on 5 and 6 September 2012.

EAME, 2004. *The Eastern African Marine Ecoregion: Biodiversity Conservation Strategic Framework 2005–2025*. 50 pp. Secretariat of Eastern African Marine Ecoregion, Dar es Salaam.

Elliott, M., Whitfield, A.K., Potter, I.C., Blaber, S.J.M., Cyrus, D.P., Nordlie, F.G. and Harrison, T.D. 2007. The guild approach to categorizing estuarine fish assemblages: a global review. *Fish and Fisheries.* **8** 241–268.

Elmer, K-H. 2007. Measurement and reduction of offshore wind turbine construction noise. *DEWI Magazine* **30** 33–36.

Emanuel, K., Sundararajan, R. and Williams, J. 2008. Hurricanes and global warming: results from downscaling IPCC AR4 simulations. *Bulletin of the American Meteorological Society*. **89(3)** 347.

EMBECOM, 2004. *Dredging-related Re-suspension of Sediments: Impacts and Guidelines for the Marine Dredging*. 72 pp. Specialist study for the environmental impact report for the pre-feasibility phase of the marine dredging project in Namdeb's Atlantic 1 Mining Licence Area and in near-shore areas off Chameis.

Environmetrics Australia, 2007. *Setting Environmental Limits: Statistical Aspects of Turbidity Monitoring*. 16 pp. Prepared for the Port of Melbourne Corporation by Environmetrics Australia (Pty) Ltd.

Equator Principles, June 2013. *The Equator Principles: A financial industry benchmark for determining, assessing and managing environmental and social risk in projects.* Available at: < http://www.equator-principles.com/resources/equator_principles_III.pdf> [Accessed November 2013].

Erftemeijer, P.L.A. and Lewis, R.R.R. 2006. Environmental impacts of dredging on seagrasses: A review. *Marine Pollution Bulletin* **52** 1553–1572.

ERM and Consultec, 2006. *EIA for the Seismic Surveys in Areas 3 & 6 in the Rovuma Basin.*

Extractive Industry Transparency Initiative (EITT), 2008. *First Report on the Extractive Industry Transparency Initiative in Mozambique: Reconciliation.* EITT, Washington DC.

Fabricius, K.E., De'ath, G., Poutinen, M.L., Done, T., Cooper, T.F. and Burgess, S.C. 2008. Disturbance gradients on inshore and offshore coral reefs caused by a severe tropical cyclone. *Limnology and Oceanography* **53** 690–704.

Fenessy, S.T., Mutombene, R., Simango, A., Cuco, C., Van der Elst, 2011. *Mozambique Line Fish Assessment 2011*. 18 pp. Research Investigation Report No. 14. Instituto Nacional de Investigação Pesqueira (National Fisheries Research Institute).

Ferro, B. and Bouman, D. 1987. *Explanatory Notes to the Hydrogeological Map of Mozambique: Scale 1:1,000,000*. Project of the Hydrogeological Map of Mozambique, sponsored by UNICEF.

Fjeldså, J., Bowie, R.C.K. and Kiure, J. 2006. The forest batis, *Batis mixta*, is two species: description of a new, narrowly distributed batis in the Eastern Arc biodiversity hotspot. *Journal of Ornithology*. **147** 578-590.

Fugro Survey Pte. Ltd, 2013. *Geophysical and Geotechnical Reconnaissance Survey Offshore Block Area 4 Mozambique*. Document No. S2835-S2102-008-N2. Prepared for Eni East Africa S.p.A. 45 pp.

Garnier, J. 2003. *Report for the Marine Programme*. Cabo Delgado Biodiversity and Tourism Project in association with the Zoological Society of London. 120 pp.

Gates, A.R. and Jones, D.O.B. 2012. Recovery of benthic megafauna from anthropogenic disturbance at a hydrocarbon drilling well (380 m depth in the Norwegian Sea). *PLoS ONE*. **7(10)** e44114. DOI: 10.1371/journal.pone.0044114.

Gauteng Department of Agriculture Environment and Conservation (GDACE), 2008. *Mining and Environmental Impact.*

Gell, F. (ed.) 1997. *The Seagrass Fishery of Quirimba Island. An Interim Report.* Issue 5 Marine Biological and Resource Use Surveys of the Quirimba Archipelago, Mozambique: Technical Report. Darwin/Frontier-Mozambique Quirimba Archipelago Marine Research Programme, Society for Environmental Exploration, UK and The Ministry for the Coordination of Environmental Affairs, Maputo.

Gibson, G.R., Bowman, M.L., Gerritsen, J. and Snyder, B.D. 2000. *Estuarine and Coastal Marine Waters: Bioassessment and Biocriteria Technical Guidance*. EPA 822-B-00-024. US Environmental Protection Agency, Office of Water, Washington DC.

Goldberg, J. and Wilkinson, C. 2004. Global threats to coral reefs: coral bleaching, global climate change. disease, predator plagues and invasive species. In: *Status of Coral Reefs of the World 2004,* Volume 1. Australian Institute of Marine Science, Townsville, Queensland, pp. 67–92.

Government of Palma District, 2012. *Annual Balance of the Economical and Social Plan 2011, Palma*.

Government of the Province of Cabo Delgado (a), 2011. *Report on the Final Balance of the Economic and Social Plan 2010.* [online] Available at: <http://w.w.w.cabodelgado.gov.mz /grandes-projectos> [Accessed February 2012].

Government of the Province of Cabo Delgado (b), 2010. *Report on the Final Balance the Economic and Social Plan 2009.* [online] Available at: <http://w.w.w.cabodelgado.gov.mz /grandes-projectos> [Accessed February 2012].

Government of the Province of Cabo Delgado (c), N.D. *Strategic Development Plan 2010-2014.* [online] Available at: <http://w.w.w.cabodelgado.gov.mz/grandes-projectos> [Accessed February 2012].

Government of the Province of Cabo Delgado (d), 2009. *Balance of Performance of the Tourism Sector during the Period 2005/2009.* [online] Available at: <http://w.w.w.cabo delgado.gov.mz/grandes-projectos> [Accessed February 2012].

Hammett, D.S. 1985. *Drill Vessels Float in Aerated Water*. Paper presented at Offshore Europe conference, 10-13 September 1985, Aberdeen.

Harmelin-Vivien, M. 1994. The effects of storms and cyclones on coral reefs: A review. *Journal of Coastal Research* **12** 211–231.

Hastings, 1990. In: Turnpenny, W.H. and Nedwell, J.R. 1994. *The Effects on Marine Fish, Diving Mammals and Birds of Underwater Sound Generated by Seismic*

Surveys. Consultancy report proposed for UKOOA by Fawley Aquatic Research Laboratories Ltd.

Hill, N. and Garnier, J. 2003. Monitoring of populations of endangered species. In: Garnier, J. (ed.) *Report on Marine Programme, November 2003,* pp. 54–69. Cabo Delgado Biodiversity and Tourism Project.

Hockey, P.A.R. 2005. Crab plover. In: Hockey, P.A.R., Dean, W.R.J. and Ryan, P.G. (eds) *Roberts – Birds of Southern Africa,* VIIth ed. The Trustees of the John Voelcker Bird Book Fund, Cape Town.

Hockey, P. and Aspinall, S.J. 1996. The crab plover: enigmatic wader of the desert coasts. *Africa Birds & Birding.* **1(1)** 60-67.

Hutchings, P. 1992. Ballast water introduction of exotic marine organisms into Australia. Current status and management options. *Marine Pollution Bulletin*. **25** 196–199.

IMO, N.D. *1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972.* [online] Available at: <http://www.imo.org/ourwork/environment/pollutionprevention/pages/1996-protocol-to-the-convention-on-the-prevention-of-marine-pollution-by-dumping-of-wastes-and-other-matter,-1972.aspx> [Accessed 15 April 2013].

Impacto, 2008. *EIA for Shallow Water Exploration Seismic Survey and Exploration Drilling in Rovuma Area 1*. Impacto, Maputo.

Instituto de Investigacao Agronomica De Mocambique, 1972. *Cartos dos Solos*. Scale: 1: 4 000 000.

Instituto Nacional de Estatística (INE) (Mozambican National Institute of Statistics) (a), 2007. *Population and Social Indicators - Population Projected by Area of Residence and Sex, According to Age, Cabo Delgado*. [online] Available at: <http://www.ine.gov.mz/home:page/censo 97> [Accessed February 2012].

Instituto Nacional de Estatística (INE) (Mozambican National Institute of Statistics) (b), 2007. *Population and Social Indicators - Basic Indicators, Province of Cabo Delgado*. [online] Available at: <http://www.ine.gov.mz/home:page/censo 97> [Accessed February 2012].

Instituto Nacional de Estatística (INE) (Mozambican National Institute of Statistics) (c), 2007. *Tables of the 3rd General Census of Population and Housing – Table 30 Occupied Population 15 years and Older by Position in the Working Process, According to Area of Residence, Sex, and Sector of Activity*. [online] Available at: <http://www.ine.gov.mz/home:page/censo 97> [Accessed February 2012].

Instituto Nacional de Estatística (INE) (Mozambican National Institute of Statistics) (d), 2007. *Tables of the 3rd General Census of Population and Housing:*

Table 32 - Occupied Population 15 Years and Older by Level of Education, According to Area of Residence, Sex, and Main Occupation. [online] Available at: <http://www.ine.gov.mz/home:page/censo 97> [Accessed February 2012].

Instituto Nacional de Estatística (INE) (Mozambican National Institute of Statistics) (e), 2010. *District Statistics (Statistics of the District of Palma).* INE, Maputo.

Instituto Nacional de Estatística (INE) (Mozambican National Institute of Statistics) (f), 2007. *Tables of the 3rd General Census of Population and Housing: Table 3 Population by Age According to District, Area of Residence, and Sex: Administrative Post of Palma, Olumbe, Pundanhar, Quionga*. [online] Available at: <http://www.ine.gov.mz/home:page/censo 97> [Accessed February 2012].

Instituto Nacional de Estatística (INE) (Mozambican National Institute of Statistics) (g), 2009. *Summary of the Final Results of the 3rd General Census of Population and Housing, Province of Cabo Delgado*. INE, Maputo.

Instituto Nacional de Estatística (INE) (Mozambican National Institute of Statistics) (h), 2010. *Annual Forecasts of the Total Urban and Rural Population of the Districts of the Province of Cabo Delgado 2007–2040*. INE, Maputo.

Instituto Nacional de Estatística (INE) (Mozambican National Institute of Statistics), 2012. Ministério da Saúde, and M.D.I. International, *Inquérito Demográfico e de Saúde 2011 - Relatório Preliminar*.

Instituto Nacional de Estatística (INE) (Mozambican National Institute of Statistics), 2010. Ministério da Saúde, and MEASURE DHS+/ORC Macro, Inquérito Nacional de Prevalência, *Riscos Comportamentais e Informação sobre o HIV e SIDA em Moçambique* (INSIDA) 2009.

Instituto Nacional de Gestão de Calamidades (INGC), 2009. *INGC Climate Change Report: Study on the Impact of Climate Change on Disaster Risk in Mozambique*. INGC, Mozambique.

Instituto Nacional de Investigação Pesqueira (IIP) (National Fisheries Institute), 2010. *Annual Report 2009*. IIP, Maputo.

Instituto Nacional de Investigação Pesqueira (IIP) (National Fisheries Institute), 2011. *Annual Report 2010*. IIP, Maputo.

Instituto Nacional de Investigação Pesqueira (IIP) (National Fisheries Institute), 2012. *Annual Report 2011*. IIP, Maputo.

Instituto Nacional do Petróleo (INP) (National Petroleum Institute), 2012. *History of Petroleum Exploration in Mozambique.* [online] Available at: <http://www.inp.gov.mz/Exploration-Production/History-of-Petroleum-Exploration-in-Mozambique2> [Accessed 23 November 2012].

International Association of Oil & Gas Producers (OGP), 2003. *Environmental Aspects of the Use and Disposal of Non-aqueous Drilling Fluids Associated with Offshore Oil and Gas Operations*. 114 pp. Report No.: 342. International Association of Oil & Gas Producers.

International Association of Oil and Gas Producers (OGP), 2009. *OGP Guidelines for Waste Management with Special Focus on Areas with Limited Infrastructure.* Report No. 413, rev 1.1, September 2008 (updated March 2009). [online] Available at: <http://www.ogp.org.uk/pubs/413.pdf> [Accessed 15 April 2013]..

International Finance Corporation (IFC), 2007. *Environmental, Health, and Safety Guidelines for Liquefied Natural Gas (LNG) Facilities.* [online] Available at: <http://www1.ifc.org/wps/wcm/connect/87e7a48048855295ac04fe6a6515bb18/Final%2B-%2BLNG.pdf?MOD=AJPERES&id=1323161924903> [Accessed 15 April 2013].

International Finance Corporation (IFC), 2007. *Environmental, Health, and Safety Guidelines: Environmental, Health, and Safety General Guidelines*. [online] Available at: <http://www1.ifc.org/wps/wcm/connect/554e8d80488658e4b76af76a6515bb18/Final%2B-%2BGeneral%2BEHS%2BGuidelines.pdf?MOD=AJPERES> [Accessed 16 April 2013].

International Finance Corporation (IFC), 2007. *Environmental, Health, and Safety Guidelines for Offshore Oil and Gas Development.* [online] Available at: <http://www1.ifc.org/wps/wcm/connect/65f8ae00488558a380d4d26a6515bb18/Final%2B-%2BOffshore%2BOil%2Band%2BGas%2BDevelopment.pdf?MOD=AJPERES&id=1323153218959> [Accessed 16 April 2013].

International Finance Corporation (IFC), 2007. *Environmental, Health, and Safety Guidelines for Ports, Harbors, and Terminals*. [online] Available at: <http://www1.ifc.org/wps/wcm/connect/9e558c00488556ebbaf4fa6a6515bb18/Final%2B-%2BPorts%252C%2BHarbors%2Band%2BTerminals.pdf?MOD=AJPERES&id=1323152828015> [Accessed 16 April 2013].

International Finance Corporation (IFC), 2012. *Performance Standards on Environmental and Social Sustainability*. [online] Available at: <http://www1.ifc.org/wps/wcm/connect/115482804a0255db96fbffd1a5d13d27/PS_English_2012_Full-Document.pdf?MOD=AJPERES> [Accessed 15 April 2013].

International Maritime Organisation (IMO), N.D. *Introduction*. [online] Available at: <http://www.imo.org/About/Conventions/Pages/Home.aspx> [Accessed 15 April 2013].

Instituto Nacional da Marinha (INAMAR) (Maritime Authority), 2010. *Map of Traditional Navigation Routes in the Indian Ocean and Mozambique Channel*.

International Monetary Fund (IMF), 2011. *Mozambique Poverty Reduction Strategy Paper.* IMF Country Report No. 11/132 (June 2011). International Monetary Fund, Washington DC.

International Monetary Fund (IMF), Republic of Mozambique, 2011. *Third Evaluation in the Scope of the Support to the Economic Policy and Request for Modification of Performance Criteria*. IMF, Washington DC.

International Union for Conservation of Nature (IUCN), 2010. *IUCN Red List of Threatened Species*, 2010. [online] Available at: <www.iucnredlist.org> [Accessed 16 April 2013].

International Union for Conservation of Nature (IUCN), 2011. *IUCN Red List of Threatened Species,* version 2011.2. [online] Available at: <www.iucnredlist.org> [Accessed 28 May 2012].

International Union for Conservation of Nature (IUCN), 2012. *IUCN Red List of Threatened Species*, 2012. [online] Available at: <www.iucnredlist.org> [Accessed 16 April 2013].

International Union for Conservation of Nature (IUCN), N.D. *Invasive Species*. [online] Available at: <http://www.iucn.org/about/union/secretariat/offices/iucnmed/iucn_med_programme/species/invasive_species/> [Accessed 16 April 2013].

Interview with District Service for Planning and Infrastructure, January 2012 (Impacto field visit, January 2012).

IWC, 2004. *Marine Mammal Auditory Systems: A Summary of Audiometric and Anatomical Data and Implications for Underwater Acoustic Impacts*. 6 pp. Annex K: Standing Working Group on Environmental Concerns Report (May 2004). Submitted at the IWC56 meeting, July 2004.

Izon, D., Danenberger, E.P. and Mayes, M. (Minerals Management Service) 2007. Absence of fatalities in blowouts encouraging in MMS Study of OCS incidents 1992-2006. *Drilling Contractor.* **July/Aug** 84–90.

Jamine, E.B. 2007. *Delimitation of the Mozambique Maritime Boundaries with Neighbouring States (including the Extended Continental Shelf) and the Management of Ocean Issues.* The United Nations and Nippon Fellowship Programme 2006-2007. [online] Available at: <www.un.org/Depts/los/nippon/unnff_programme_home/fellows_pages/fellows_papers/jamine_0607_mozambique.pdf> [Accessed 18 May 2012].

Key, R., Smith, R., Smelror, M., Saether, O., Thorsnes, T., Powell, J., Njange, F. and Zandamel, E. 2008. Revised lithostratigraphy of the Mesozoic-Cenozoic succession of the onshore Rovuma Basin, northern coastal Mozambique. *South African Journal of Geology*. **Vol. 111** 89-108.

Kleynhans, C.J. and Louw, M.D. 2008. *Module A: EcoClassification and Ecostatus Determination in River EcoClassification: Manual for Ecostatus Determination,* Version 2. Joint Water Research Commission and Department of Water Affairs and Forestry, Pretoria.

Kleynhans, C.J. 1996. A qualitative procedure for the assessment of habitat integrity status of the Levuvhu River (Limpopo system South Africa). *Journal of Aquatic Ecosystem Health*. **5** 41–54.

Kleynhans, C.J. 1999. *Comprehensive Habitat Integrity Assessment*. Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria.

Kleynhans, C.J., Mackenzie, J. and Louw, M.D. 2007. *Module F: Riparian Vegetation Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination*, Version 2. Joint Water Research Commission and Department of Water Affairs and Forestry, Pretoria.

Kotze, D.C, Marneweck, G.C, Batchelor, A.L., Lindley, D.S. and Collins, N.B. 2007. *WET-EcoServices: A Technique for Rapidly Assessing Ecosystem Services Supplied by Wetlands*. WRC Report No TT 339/08. Water Research Commission, Pretoria.

Lamb, T., Biswas, S. and Bauer, A.M. 2010. A phylogenetic reassessment of African fossorial skinks in the subfamily Acontinae (Squamata: Scincidae): evidence for parallelism and polyphyly. *Zootaxa*. **2657** 33–46.

Lamberth, S.J. and Turpie, J.K. 2003. The role of estuaries in South African fisheries: economic importance and management implications. *African Journal of Marine Science.* **25** 131–157.

Larsson, A.I. and Purser, A. 2011. Sedimentation on the cold-water coral *Lophelia pertusa*: cleaning efficiency from natural sediments and drill cuttings. *Marine Pollution Bulletin*. **62** 1159–1168.

Laws, E.A. 2000. *Aquatic Pollution – An Introductory Text*. John Wiley and sons, New York.

Lenhoff, L. N.D. Underwater Surveys (UWS), Cape Town, *in litt.*

Lepage, D. 2012. *Checklist of the Birds of Mozambique*. Avibase, the world database. [online] Available at: <http://avibase.bsc-eoc.org/checklist.jsp?lang=EN&region=mz&list=clements> [Accessed on 16 April 2013].

LGL, 2010. *Marine Seismic Survey on the Shatsky Rise in the Northwest Pacific Ocean, June-July 2010*. 213 pp. Draft Environmental Assessment (DEA) Pursuant to the National Environmental Policy Act, 42 U.S.C. 4321, et seq. LGL Ltd., King City, Ont.

Liesegang, G. 1986. *Ngungunyane: A figura de Ngungunyane Nqumayo, Rei de Gaza 1884-1895 e o desaparecimento do seu Estado*. Colecção Embondeiro, 8. Maputo: Arquivo do Património Cultural.

Luiselli, L. and Akani, G.C. 2002. An investigation into the composition, complexity and functioning of snake communities in the mangroves of south-eastern Nigeria. *African Journal of Ecology.* **40** 220–227.

Lutjeharms, J.R.E. 2006. The coastal oceans of south-eastern Africa. In: Robinson, A.R. and Brink, K.H. (eds) *The Global Coastal Ocean: The Sea – Ideas and Observations on the Progress in the Study of the Seas.* **14 (b)** 783–834. Harvard University Press, Cambridge, MA.

Lwandle Technologies (Pty) Ltd., 2012. *Anadarko and Eni LNG Development, Northern Mozambique: Marine Ecology Assessment*. Prepared for ERM (Pty) Ltd.

MacDonald, A. and Davies, J. 2000. *A Brief Review of Groundwater for Rural Water Supply in Sub-Saharan Africa.* Technical Report WC/00/33. British Geological Survey.

Macpherson, E. 2002. Large-scale species-richness gradients in the Atlantic Ocean. *Proceedings of the Royal Society of London*. **B(269)** 1715–1720.

Madsen, P.T., Wahlberg, M., Tougaard, J., Lucke, K. and Tyack, P. 2006. Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs. *Marine Ecology Progress Series.* **309** 279–295.

Marchand, M.J. 2009. *A Histology-based Fish Health Assessment to Determine the Health Status and Edibility of Two Indicator Species from the Roodeplaat Dam.* M.Sc. Mini-dissertation. University of Johannesburg, Johannesburg.

Matuschek, R. and Betke, K. 2009. *Measurements of Construction Noise during Pile Driving of Offshore Research Platforms and Wind Farms*. 4 pp. NAG/DAGA, Rotterdam.

Maurer, D., Keck, R.T., Tinsman, J.C. and Leathem, W.A. 1980. Vertical migration and mortality of benthos in dredged material – Part 1: Mollusca. *Marine Environmental Research.* **4** 299–319.

Maurer, D., Keck, R.T., Tinsman, J.C. and Leathem, W.A. 1981. Vertical migration and mortality of benthos in dredged material – Part 2: Crustacea. *Marine Environmental Research.* **5** 301–317.

Maurer, D., Keck, R.T., Tinsman, J.C. and Leathem, W.A. 1982. Vertical migration and mortality of benthos in dredged material – Part 3: Polychaeta. *Marine Environmental Research.* **6** 49–68.

McCauley, R.D. 1994. Seismic surveys. In: Swan, J.M., Neff, J.M. and Young, P.C. (eds) *Environmental Implications of Offshore Oil and Gas Development in Australia - The Findings of an Independent Scientific Review.* APEA, Sydney, pp. 19–121.

McCauley, R.D., Fewtrell, J. and Popper, A.N. 2003. High intensity anthropogenic sound damages fish ears. *Journal Acoustical Society of America*. **113** 638–641.

Ministry for Coordination of Environmental Affairs (MICOA), 2013. *Strategic Environmental Assessment for the Coastal Zone of Mozambique:* Palma District Profile, Cabo Delgado Province. Final Version.

Milgram, J. and Erb, P.R. 1984. How floaters respond to subsea blowouts. *Petroleum Engineer International.* **June** 64–70.

Milton, S., Lutz, P. and Shigenaka, G. 2008 Oil toxicity and impacts. In: Milton, S., Lutz, P. and Shigenaka, G. *Oil and Sea Turtles*. NOAA's national Ocean Service Office of Response and Restoration.

Ministry for the Coordination of Environmental Affairs, 2009. The National Report on Implementation of the Convention on Biological Diversity in Mozambique. [online] Available at: <www.cbd.int/doc/world/mz/mz-nr-04-en.pdf> [Accessed 16 April 2013].

Ministry of Fishing (Ministério das Pescas) (c), 2008. *National Survey of Small-Scale Fishing 2007*. Ministry of Fishing, Maputo.

Moffatt & Nichol, 2011. *Dredging Trade-off Study*. 58 pp. Doc No. EA-MZ-FA0000-MON-P09-0001-00. For APC-Mozambique LNG Project.

Moffat & Nichol, 2012. *EA-MZ-FA0000-MON-P09-00004-00 Meteorological Data Analysis: Mozambique Project*. Rev A. (May 2012).

Moffat & Nichol, 2012. *EA-MZ-FA0000-MON-P09-00006-00 Sea Level Rise Study: Mozambique Project*. Rev A. (August 2012).

Motta, H., Pereira, M.A.M., Gonçalves, M., Ridgway, T. and Schleyer, M. 2002. *Coral Reef Monitoring in Mozambique. II: 2000 Report*. 31 pp. Mozambique Coral Reef Management Programme. MICOA/CORDIO/ORI/WWF, Maputo.

Motta, H., Rodrigues, M.J. and Schleyer, M. 2000. Coral reef monitoring and Management in Mozambique. In: Souter, D., Obura, D. and Linden, O. (eds)

Coral Reef Degradation in the Indian Ocean. Status Report 2000, pp. 43–48. CORDIO.

Mozambican Ministry of Planning and Development, Office of the National Director of Studies and Analysis of Policies, Poverty, and Wellbeing in Mozambique, 2010. *Poverty and Well-being in Mozambique: Third National Evaluation.* Mozambican Ministry of Planning and Development, Maputo.

MSI, 2012. *P1. Draft Data Report V1*. 301 pp. Prepared for Anadarko Area 1 Lda.

Nagelkerken, I., Blaber, S.J.M., Bouillon, S., Green, P., Haywood, M., Kirton, L.G., Meynecke, J.-O., Pawlik, J., Penrose, H.M., Sasekumar, A. and Somerfield, P.J. 2008. The habitat function of mangroves for terrestrial and marine fauna: a review. *Aquatic Botany*. **89** 155–185.

National Institute of Meteorology (INAM), 2011. Meteorological data.

National Malaria Control Programme, 2007. National Malaria Indicator Survey Mozambique, 2007.

National Oceanographic and Atmospheric Administration (NOAA), N.D. [online] Available at: <http://www.noaa.gov/> [Accessed 16 April 2013].

NATO Shipping Centre, Information Report to the Maputo Workshop, May 2011.

Natural Scientific Services cc (NSS), 2012. *The Wetlands and Onshore Aquatic Ecological Status of Watercourses in the Vicinity of the Proposed LNG Facilities and Supporting Infrastructure, Cabo Delgado Province, Mozambique.*

Neff, J.M, McKelvie, S. and Ayers, A.R.C. Jr. 2000. *Environmental Impacts of Synthetic Based Drilling Fluids*. 111 pp. OCS Study MMS 2000-064. Report prepared for MMS by Robert Ayers & Associates, August 2000. U.S. Department of the Interior, Minerals Management Service Gulf of Mexico OCS Region, New Orleans, LA.

Newell, R.C., Seiderer, L.J. and Hitchcock, D.R. 1998. The impact of dredging works in coastal waters: a review of the sensitivity to disturbance and subsequent recovery of biological resources on the seabed. *Oceanography and Marine Biology: an Annual Review*. **36** 127–78.

Newman, K. 2002. *Newman's Birds of Southern Africa.* 527 pp. Struik Publishers, Cape Town.

Ngupula, G.W. and Kayanda, R. 2010. Benthic macrofauna community composition, abundance and distribution in the Tanzanian and Ugandan inshore and offshore waters of Lake Victoria. *African Journal of Aquatic Science***. 35(2)** 185–192.

Nightingale, B. and Siminstad, C.A. 2001. *Dredging Activities: Marine Issues. Washington State Transportation Centre (TRAC).* Report No. WA-RD 507.1. Washington, United States of America.

NRC, 2003. *Ocean Noise and Marine Mammals*. 221 pp. Ocean Studies Board. The National Academies Press, Washington, DC.

Ntumi, C.P., Ferreira, S.M. and Van Aarde, R.J. 2009. A review of historical trends in the distribution and abundance of elephants *Loxodonta africana* in Mozambique. *Oryx*. **43(4)** 568-579.

Obura, D., Suleiman, M., Motta, H. and Schleyer, M. 2000. Status of coral reefs in East Africa: Kenya, Mozambique, South Africa and Tanzania. In: Wilkinson, C.R. (ed.) *Status of Coral Reefs of the World: 2000*. Australian Institute of Marine Science, Cape Ferguson, Queensland, pp. 65–76.

Obura, D. 2012. The diversity and biogeography of Western Indian Ocean reef-building corals. PloS ONE 7(9): e45013 doi:10.1371/journal.pone.0045013.

OSPAR Commission, N. D. *OSPAR List of Substances Used and Discharged Offshore which are Considered to Pose Little or No Risk to the Environment (PLONAR).* OSPAR Agreement 2012-06. [online] Available at: <http://www.ospar.org/v_measures/browse.asp?menu=01110305120125_000002_000000> [Accessed 15 April 2013].

Palma District Services for Planning and Infrastructures, 2011. Data collected during Impacto field visit, November 2011.

Palma District Services of Education, Youth and Technology, 2012. Data collected during Impacto field visit, January 2012.

Palma District Services of Health, Women and Social Action, 2012. Data collected during Impacto field visit, January 2012.

Parker, V. 2001. Mozambique. In: Fishpool, L.D.C. and Evans, M.I. (eds) *Important Bird Areas in Africa and Associated Islands: Priority Sites for Conservation.* BirdLife Conservation Series No. 11, pp. 897-945. Pisces Publications and BirdLife International, Newbury and Cambridge, UK.

Parker, V. 2005. *The Atlas of the Birds of Central Mozambique*. Endangered Wildlife Trust and Avian Demography Unit, University of Cape Town, Johannesburg and Cape Town.

Parsons, T.R., Takahashi, M. and Hargrave, B. 1977. *Biological Oceanographic Processes*. 332 pp. Pergamon Press, New York.

Patin, S. 1999. *Environmental Impact of the Offshore Oil and Gas Industry*. EcoMonitor Publishing, New York.

Pearson, W.H., Skalski, J.R. and Malme, C.I. 1992. Effects of sounds from a geophysical survey device on behavior of captive rockfish (Sebastes spp.). *Canadian Journal of Fisheries and Aquatic Sciences.* **49** 1343–1356.
Peddemors, V.M., Best, P.B., Findlay, K.P., Gove, D., Rakotonirina, B., Rossouw, A. and Sekiguchi, K. 1997. *Small Cetaceans of the South-west Indian Ocean.* Paper SC/49/SM33, presented to the International Whaling Commission Scientific Committee, October 1997.

Pereira, M.A.M. 2000. *Preliminary Checklist of Reef-associated Fishes of Mozambique*. 22 pp. CDS-MICOA, Maputo.

PIANC, 2010. *Dredging and Port Construction around Coral Reefs*. 94 pp. Rept No. 108.

Pires, J. 2009. *Institutional Arrangements for the Provision of Safe Drinking Water in Mozambique*. Water Regulatory Council of Mozambique. [online] Available at: <http://iwahq.org/ContentSuite/upload/iwa/Document/Water_Quality_MZ.pdf> [Accessed 23 October 2012].

Pitty, A.F. 1979. *Geography and Soil Properties*. Methuen, London.

Popper, A.N., Carlson, T.J., Hawkins, A.D., Southall, B.L. and Gentry, R.L. 2006. *Interim Criteria for Injury of Fish Exposed to Pile Driving Operations: A White Paper.* 15 pp.

Prestedge Retief Dresner Wijnberg (Pty) Ltd (PRDW), 2012. *Marine Specialist Study, Specialist Report.* 114 pp. Compiled by PRDW for Environmental Resource Management and Anadarko Mozambique Àrea 1, Limitada Liquified Natural Gas Project in Cabo Delgado.

Provincial Tourism Directorate, 2008. *Areas with Potential for Tourism Development.* PowerPoint presentation during Impacto field visit, November 2011.

Provincial Directorate of Tourism of Cabo Delgado, 2011. Data collected during Impacto field visit, November 2011.

Provincial Services of Geography and Land Registry, 2011. Data collected during Impacto field visit, November 2011.

Ramanathan, A.L., Subramanian, V., Ramesh, R., Chidambaran, S. and James, A. 1999. Environmental geochemistry of the Pichavaran mangrove ecosystem (tropical), southeast coast of India. *Environmental Geology.* **37(3)** 223–233.

Reid, S.M. and Anderson, P.G. 1999. Effect of sediment released during open-cut pipeline water crossings on stream and river ecosystems. *Canadian Water Resources Journal.* **24** 23–39.

Richardson, W.J., Greene, C.R.G. Jr, Malme, C.I. and Thomson, D.H. 1995. *Marine Mammals and Noise*. 576 pp. Academic Press, San Diego.

Richmond, R.H. 1997. Reproduction and recruitment in corals. In: Birkeland, C. (ed.) *Life and Death of Coral Reefs*. Chapman and Hall, New York, pp. 175–197.

Richmond, M.D. (ed.) 2002. *A Guide to the Seashores of Eastern Africa and the Western Indian Ocean Islands*. 461 pp. SIDA/SAREC-UDSM.

Ridderinkhof, H. and De Ruijter, W.P.M. 2003. Moored current observations in the Mozambique Channel. *Deep-Sea Research II.* **50** 1933-1955.

Roark, E.B., Guilderson, T.P., Dunbar, R.B., Fallon, S.J. and Mucciarone, D.A. 2009. Extreme longevity in proteinaceous deep-sea corals. *Proceedings of the National Academy of Sciences USA.* **106** 5204–5208.

Roberts, J.R. (ed.), 2001. *Fish pathology*. W.B. Saunders, Harcourt Publishers Ltd, London.

Rodrigues, M., Motta, H., Whittington, M.W. and Schleyer, M. 2000. Coral reefs of Mozambique. In: McClanahan, T.R., Sheppard, C.R.C. and Obura, D. (eds) *Coral Reefs of the Indian Ocean: Their Ecology and Conservation*. 525 pp. Oxford University Press, pp. 107–129.

Romanov, E.V. 2002. Bycatch in the tuna purse-seine fisheries of the western Indian Ocean. *Fisheries Bulletin.* **100(1)** 90–105.

Rose, P.M. and Scott, D.A. 1997. *Waterfowl Population Estimates*. Wetlands International Publication 44. Wetlands International, Wageningen.

Rotter G, Huslimlsche Inseln vor Ostafrika, 1976. *Eine Arabische Komoren-Chronik aus 19. Jahrhunderts.* Beiruter Texte und Studien, 18, Orient-Institut der Deutschen Morgenlandischen Gesellschaft, Franz Steiner Verlag, Beirut 1976.

RPS Energy, 2010. *Marine Mammal Observers and Passive Acoustic Monitoring Operators Report during 3D Survey Rovuma Basin Area 4 for ENI East Africa.* 58 pp. Report EOM1236.

Ruiz, G.M. and Smith, G. 2005. *Biological Study of Container Vessels at the Port of Oakland. Final report*. 155 pp. Submitted to the Port of Oakland.

Ruvuma River Basin, N.D. *Development of the Ruvuma River Basin Monograph and Joint Integrated Water Resources Management Strategy*. [online] Available at: <http://ruvumariver.org/> [Accessed 16 April 2013].

Rzewuski Eugeniusz, 1979. Vocabulário da lingua mwani. (Versão provisória), Universidade Eduardo Mondlane: Maputo, (stencil copy).

Sætre, R. and De Paula e Silva, R. 1979. *The Marine Fish Resources of Mozambique*. 179 pp. Reports on surveys with the R/V Dr Fridtjof Nansen, Serviço de Investigações Pesqueiras, Maputo. Institute of Marine Research, Bergen.

Sætre, R. and Jorge da Silva, A 1982. *Water Masses and Circulation of the Mozambique Channel*. 83 pp. Revista de Investigação Pesquira, 3, Instituto de Desenvolvimento Pesqueiro, Maputo.

Sætre, R. and Jorge da Silva, A. 1984. The circulation of the Mozambique Channel. *Deep-Sea Research*. **31** 485–508.

Santulli, A., Modica, A., Messina, C., Ceffa, L., Curatolo, A., Rivas, G., Fabi, G. and D'Amelio, V. 1999. Biochemical responses of European Sea Bass (Dicentrarchus labrax L.) to the stress induced by off shore experimental seismic prospecting. *Marine Pollution Bulletin.* **38** 1105–1114.

Schleyer, M.H., Obura, D., Motta, H. and Rodrigues, M.J. 1999. A preliminary assessment of coral bleaching in Mozambique. *South African Association for Marine Biological Research Unpublished Report.* **168** 1-12.

Schouten, S., Hopmans, E.C., Kuypers, M.M.M., Van Breugel, Y., Forster, A. and Sinninghe Damsté, J.S. 2003. Extremely high sea water temperatures at low latitudes during the middle Cretaceous as revealed by archaeal membrane lipids. *Geology*. **31** 1069–1072.

Sherwood, C.R., Butman, B., Cacchione, D.A., Drake, D.E., Gross, T.F., Sternberg, R.W., Wiberg, P.L. and Williams, A.J. III 1994. Sediment transport events on the northern California continental shelf during the 1990-1991 STRESS experiment. *Continental Shelf Research.* **14(10/11)** 1063–1100.

Sinclair, I. and Ryan, P. 2003. *Birds of Africa South of the Sahara*. 759 pp. Princeton University Press, Princeton, NJ.

Sinclair, I. and Ryan, P. 2010. *Birds of Africa South of the Sahara: A Comprehensive Illustrative Guide,* 2nd edition. Struik Publishers, Cape Town.

Skelton, P. 2001. *A Complete Guide to the Freshwater Fishes of Southern Africa,* 2nd edition. 395 pp. Southern Publishers. Cape Town.

Skinner, J.D. and Chimimba, C.T. 2007. *The Mammals of the Southern African Subregion*, new edition. Cambridge University Press, South Africa.

Slotte, A., Hansen, K., Dalen, J. and Ona, E. 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.

S.L. Ross Environmental Research Ltd., SINTEF and Wellflow Dynamics, 2009. *Assessing Risk and Modeling a Sudden Gas Release Due to Gas Pipeline Ruptures*. For U.S. Department of the Interior Minerals Management Service.

Smedley, P. 2002. *Groundwater Quality: Mozambique*. WaterAid Information Sheet. British Geological Survey.

Smit, M.G.D., Holthaus, K.I.E., Trannum, H.C., Neff, J.M., Kjeilen-Eilertsen, G., Jak, R.G., Singsaas, I., Huijbregts, M.A.J. and Hendriks, A.J. 2008. Species sensitivity distributions for suspended clays, sediment burial, and grain size change in the marine environment. *Environmental Toxicology and Chemistry.* **27** 1006–1012.

Snow, G.C, Bate, G.C. and Adams, J.B. 2000. The effects of a single freshwater release into the Kromme estuary 2: microalgal response. *Water SA.* **26** 301–310.

Sobrado, M.A. 1999. Leaf photosynthesis of the mangrove *Avicennia germinans* as affected by NaCl. *Photosynthetica.* **36** 547–555.

Soil Classification Working Group, 1991. *Soil Classification: A Taxonomic System for South Africa.* Memoirs on the Agricultural Natural Resources of South Africa No. 15. Institute for Soil, Climate and Water, Pretoria.

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene, C.R. Jr, Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A. and Tyack, P.L. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals*. **33** 411–521.

Southern African Reptile Conservation Assessment (SARCA), 2012. *Southern African Herpetology*. [online] Available at: <http://sarca.adu.org.za/> [Accessed 26 April 2012].

Spalding, M., Kainuma, M. and Collins, L. 2010. *World Atlas of Mangroves*. 319 pp. Earthscan, London.

Spalding M. D., Fox, H.E., Allen, G.R., Davidson, N., Ferdaña Z.A., Finlayson, M., Halpern, B.S., Jorge, M.A., Lombana, A., Lourie, S.A., Martin, K.S., McManus, E., Molnar, J., Recchia, C.A., Robertson, J. 2007. Marine ecoregions of the world: A bioregionalization of coast and shelf areas. BioScience 57: 573-583.

Stey, G. and Dennis, I. 2009. Review of coastal-area aquifers in Africa. *Hydrogeology Journal*. **18** 217-225.

Tadross, M. 2009. *Climate Change Modelling and Analyses for Mozambique.* 32 pp. Final report detailing the support provided to the Instituto Nacional de Gestão de Calamidades (INGC) adaptation to climate change project.

Taylor, J.C. 2011. *Diatom Analysis Low Flow Report*.

Taylor, J.C. 2012. *Diatom Analysis High Flow Report*.

Thirion, C. 2008. *Module E: Macroinvertebrate Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination*, Version 2. Joint Water Research Commission and Department of Water Affairs and Forestry, Pretoria.

Timberlake, J., Goyder, D., Crawford, F. and Pascal, O. 2010. *Coastal Dry Forests in Cabo Delgado Province, Northern Mozambique: Botany & Vegetation*. 92 pp. Report for Our Planet Reviewed, a joint initiative of Pro-Natura International and the French Museum of Natural History, Royal Botanic Gardens, Kew, London.

Tinley, K.L. 1971. Determinants of coastal conservation: dynamics and diversity of the environment as exemplified by the Mozambique coast. In: *Nature Conservation as a Form of Land Use*. Proceedings of the SARCCUS Symposium, Gorongosa National Park, 13-17 September, pp. 125-153.

TRANSMAP, 2007. *Transboundary Networks of Marine Protected Areas for Integrated Conservation and Sustainable Development: Biophysical, Socio-economic and Governance Assessment in East Africa*. Funded by the European Union, INCO-CT2004-510862.

Tuffers, A., Naidoo, G. and Von Willert, D. 2001. Low salinities adversely affect photosynthesis performance of the mangrove *Avicennia marina*. *Wetlands Ecology and Management.* **9(1)** 225–232.

Turnpenny, W.H. and Nedwell, J.R. 1994. *The Effects on Marine Fish, Diving Mammals and Birds of Underwater Sound Generated by Seismic Surveys.* Consultancy report proposed for UKOOA by Fawley Aquatic Research Laboratories Ltd.

Turpie, J.K. 2005. Mangrove kingfisher. In: Hockey, P.A.R., Dean, W.R.J. and Ryan, P.G. (eds), *Roberts – Birds of Southern Africa,* VIIth ed. The Trustees of the John Voelcker Bird Book Fund, Cape Town.

Turpie, J.K., Wilson, G. & van Niekerk, L. 2010. *National Biodiversity Assessment: South African National Priority Estuaries for Biodiversity Conservation and Ecological Sustainability.* DEA: SANBI.

UNAIDS and WHO, 2008. *Epidemiological Country Profile on HIV and AIDS.* Available at: <http://apps.who.int/globalatlas/predefinedReports/EFS2008/short/EFSCountryProfiles2008_MZ.pdf>[Accessed 15 April 2013].

UNEP and E&P Forum, 1997. *Environmental Management in Oil and Gas Exploration and Production – an Overview of Issues and Management Approaches*.

[online] Available at: <http://www.ogp.org.uk/pubs/254.pdf> [Accessed 15 April 2013].

UNEP/Nairobi Convention Secretariat and CSIR, 2009. *Guidelines for the Establishment of Environmental Quality Objectives and Targets in the Coastal Zone of the Western Indian Ocean (WIO) Region*. 169 pp. UNEP, Nairobi.

UNICEF, 2010. *Child poverty and disparities in Mozambique 2010*.

United Nations Framework Convention on Climate Change (UNFCCC), 2006. *Mozambique Initial National Communication under UN Framework Convention on Climate Change*. For: Ministry for Coordination of Environmental Affairs (MICOA). [online] Available at: <http://unfccc.int/essential_background/library/items/3599.php?rec=j&prir ef=5552#beg> [Accessed 16 April 2013].

United States Environmental Protection Agency (USEPA), 2001. *Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual*. EPA 823-B-01-002. United States Environmental Protection Agency, Office of Water, Washington DC.

Underwater Survey (Pty) Ltd (UWS), 2011. Multi-beam bathymetric survey data.

United States of America Marine Fisheries Service (US NMFS), 2000. Small takes of marine mammals incidental to specified activities; marine seismic-reflection data collection in southern California/Notice of receipt of application. *Federal Register*. **65(60, 28 Mar.)** 16374-16379.

USAID, 2010. *HIV/AIDS Health Profile Mozambique*, 2010.

Valdesalici, S. 2007. A new species of the genus Nothobranchius (Cyprinodontiformes: Nothobranchiidae) from the coastal area of northeastern Mozambique. *Zootaxa*. **1587** 61–68.

Van Niekerk, L., Bate, G.C. and Whitfield, A.K. (eds), 2008. *Ecological Reserve Determination Study of the East Kleinemonde Estuary*. WRC Report No. 1581/2/08. Water Research Commission, Pretoria.

Veil, J.A., Puder, M.G., Elcock, D. and Redweik, R.J. 2004. *A White Paper Describing Produced Water from Production of Crude Oil, Natural Gas, and Coal Bed Methane*. [online] Available at: <http://www.ead.anl.gov/pub/doc/ProducedWatersWP0401.pdf> [Accessed 15 April 2013].

Velten, C. 1907. Prosa und Poesie der Suaheli, Berlin. Reproduced partially in: Freeman-Grenville, 1962. pp. 221-6.

Ward, B.B., Kilpatrick, K.A., Novelli, P.G. and Scranton, I. 1987. Methane oxidation and methane fluxes in the ocean surface layer and deep anoxic waters. *Nature*. **327** 226-229.

Wild, H. and Barbosa, L.A.G. 1967. *Vegetation Map of the Flora zambesiaca Area.* Flora zambesiaca Supplement. Collins, Salisbury, Rhodesia.

Williams, S.L. 2007. Introduced species in seagrass systems: status and concerns. *Experimental Marine Biology & Ecology*. **350** 89–110.

Wood, P.J. and Armitage, P.D. 1997. Biological effects of fine sediment in the lotic environment. *Environmental Manager*. **21(2)** 203–217.

World Bank, 2003. Mozambique Statistics. 2003. [online] Available at: <http://www.worldbank.org/en/country/mozambique>[Accessed 15 April 2013].

World Health Organization (WHO), 2005. *Air Quality Guidelines Global Update, 2005.* Report on a Working Group meeting, Bonn, Germany, 18-20 October 2005. [online] Available at: <http://www.euro.who.int/__data/assets/pdf_file/0008/147851/E87950.pdf> [Accessed 15 April 2013].

World Health Organization (WHO), 2011. *Guidelines for Drinking-water Quality*, Fourth Edition. WHO, Geneva.

World Ocean Atlas, 2009. *World Ocean Atlas 2009*. [online] Available at: <http://www.nodc.noaa.gov/OC5/WOA09/pr_woa09.html> [Accessed 17 January 2013].

World Register of Marine Species (WoRMS), N.D. [online] Available at: <http://www.marinespecies.org/> [Accessed 15 April 2013]

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