Chapter 12

Onshore Environmental Impact Assessment and Mitigation

CONTENTS

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).

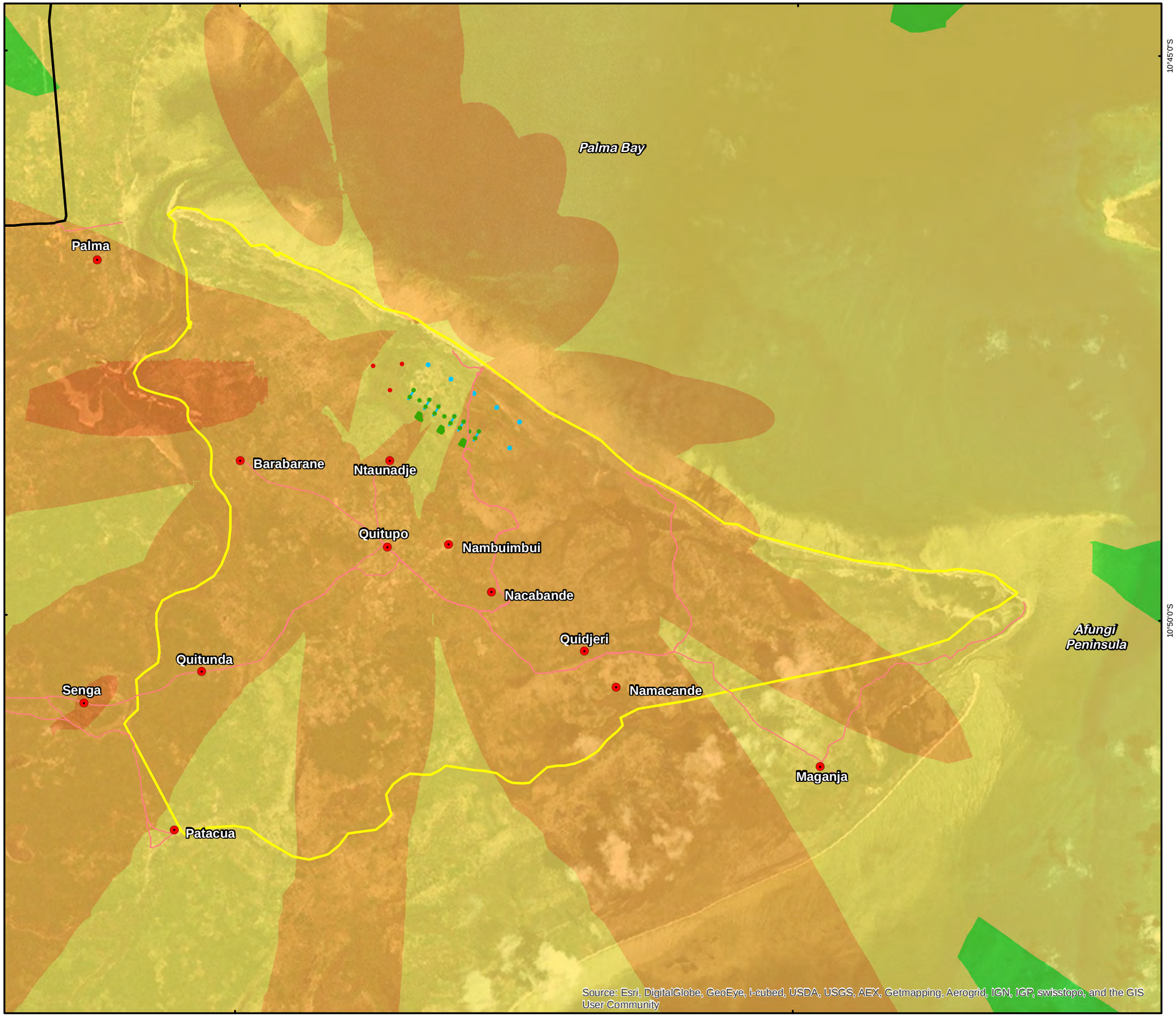
Contour plots (*Figure 12.2* and *Figure 12.3*) have been generated to show the dispersion of SO_2 emissions from the LNG Facility in these scenarios.

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.



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
240 Main Road
Rondebosch, 7725
Cape Town, SOUTH AFRICA
Tel: +27 21 681 5400
Fax +27 21 686 073

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

Afungi Peninsula

Maganja

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

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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
DRAWN: AB	APPROVED: KG	SCALE: 1 : 60 000

DRAWING: Short term (24hr max) SO2 Impact during Normal Operation.mxd

REV: A

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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

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:

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Kilometers

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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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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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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.

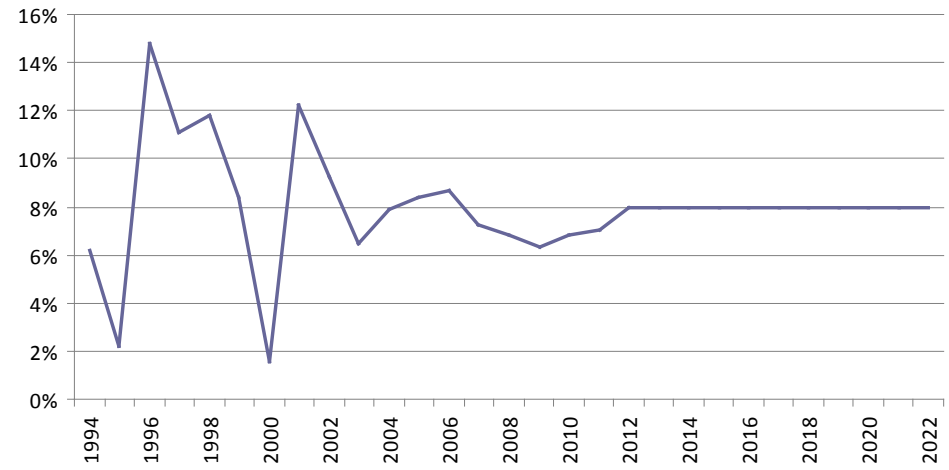
Table 12.6 Mozambique's National GHG Emissions 1990 and 1994

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

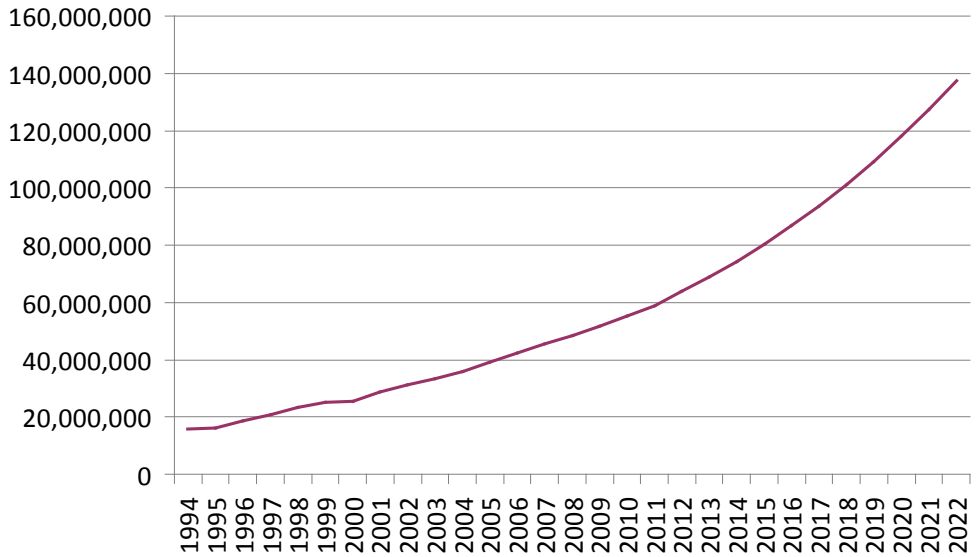


Source: World Bank Data.

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***



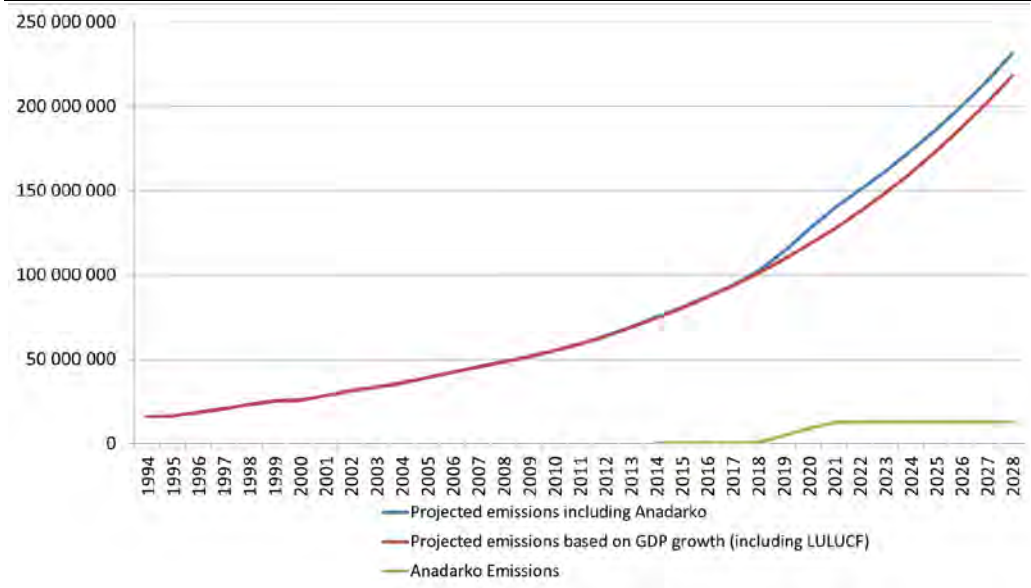
Source: ERM, 2012.

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.

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

Quiwia
Cabo Delgado Peninsula
Palma Bay
NSR 5
NSR 3
NSR 6
NSR 2
Palma
NSR 1
Tecomaji Island
Manguna
Nkalanga
Macala
Quitupo
NSR 7
Afungi Peninsula
Senga
NSR 4
Maganja
Nkumbi
Rongui Island
Matapata
Queramimbi Island

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Legend

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

MAIN MAP SCALE:

0 2 4 6
Kilometers

N

TITLE:

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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Fax +27 21 686 073

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

SIZE: A3

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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

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

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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

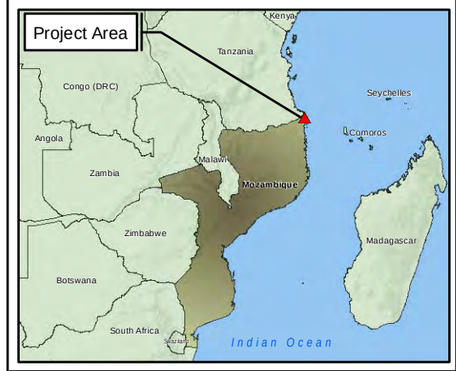
Legend

- 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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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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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 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
OPERATIONS SUPPORT AREA
AIR STRIP PASSENGER TERMINAL
AIR STRIP
Afungi Peninsula
Senga
NSR 4
Maganja
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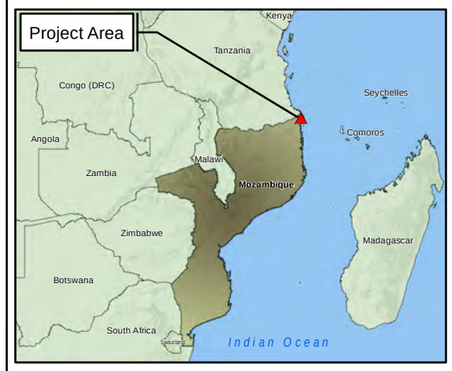
Legend

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

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

N

TITLE:

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

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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 1

NSR 2

NSR 3

NSR 4

NSR 5

NSR 6

NSR 7

Palma

Manguna

Barabarane

Ntaunadje

Quitupo

Nambuimbui

Nacabande

Nkalanga

Macala

Quitunda

Quidjeri

Senga

Namacande

Maganja

Nkumbi

Patacua

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

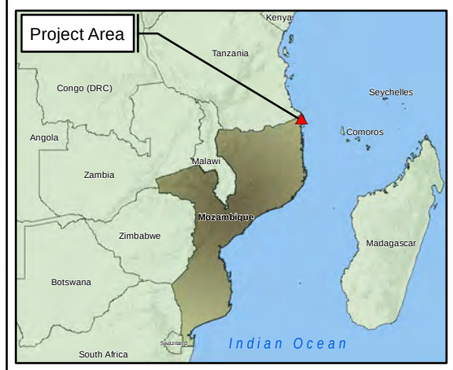
Legend

- 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

eni

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

DRAWING: Aircraft Noise Levels - Antonov 124.mxd

REV: A

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Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
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SIZE: A3

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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.

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
Afungi Peninsula
Rongui
Qeramimbi
Olumbe
Cabo Nondo
Vamizi
1
2
3
4
5
6
7
8
9

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

CLIENT: Anadarko Moçambique Área 1, Lda / eni

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

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

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

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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

bing

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

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_Flare_Stack.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
Tecomaji Island
Palma
Quitupo
Afungi Peninsula
Senga
Maganja
Rongui Island
Aienda
Queramimbi Island
Bawala
Olumbe
Vamizi Island

bing™

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

CLIENT:

Anadarko Moçambique Área 1, Lda

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

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ERM

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

Tecomaji Island

Palma

Quitupo

Afungi Peninsula

Senga

Maganja

Rongui Island

Aienda

Queramimbi Island

Bawala

Olumbe

Vamizi Island

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© Harris Corp, Earthstar Geographics LLC State of Michigan

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

Tecomaji Island

Palma

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

eni

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

DRAWING: ZTV_Nearshore.mxd

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ERM

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Source: ERM, 2012
Inset Map: Esri Data & Maps

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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.

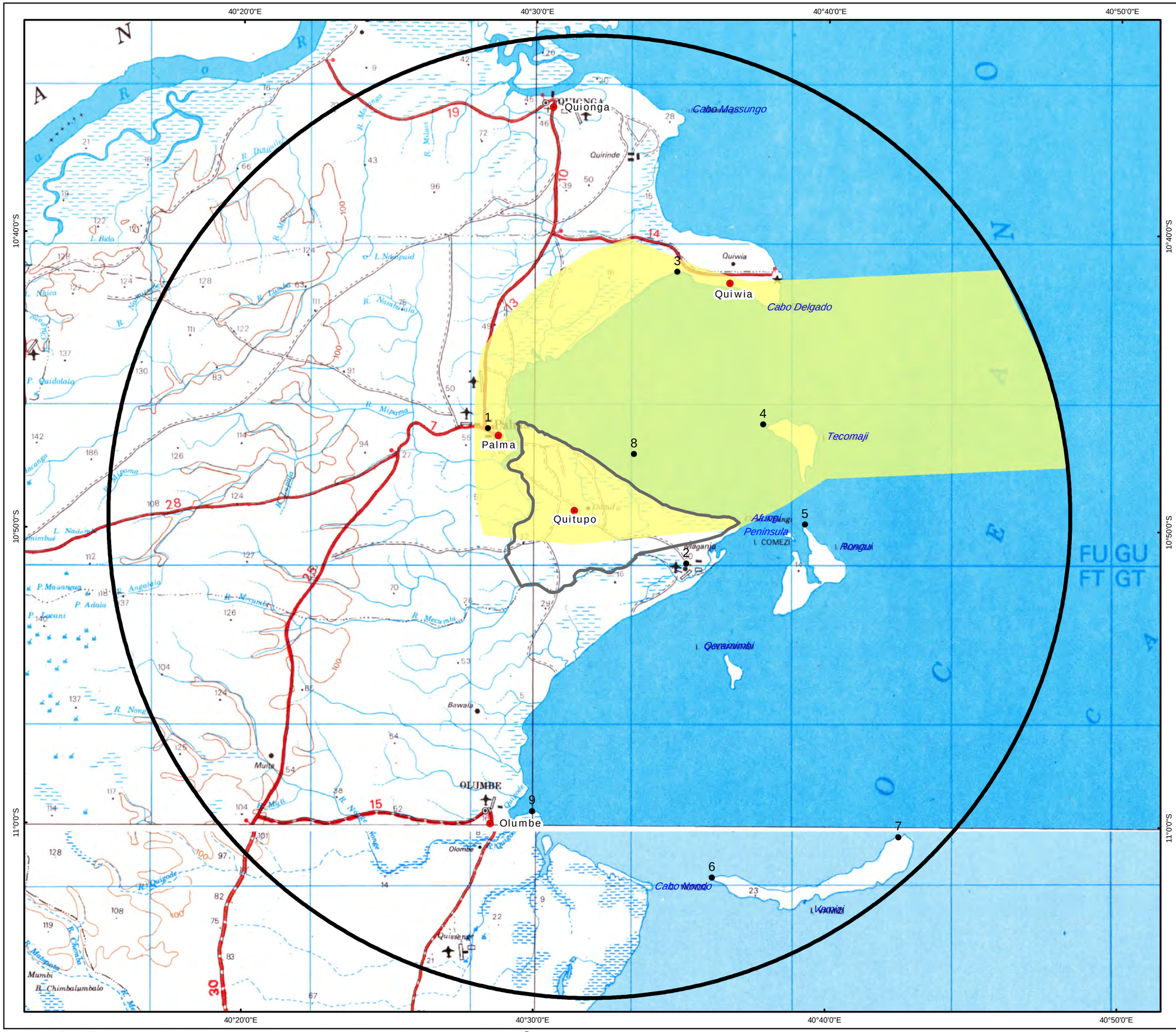
Construction

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.



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
Inset Map: Esri Data & Maps

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. VAMIZI
Vamizi
I. TECOMAJI
Tecomaji

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

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

ERM
Great Westerford Building
240 Main Road
Rondebosch, 7725
Cape Town, SOUTH AFRICA
Tel: +27 21 681 5400
Fax +27 21 686 073

Impacto Projectos e Estudos Ambientais / ERM

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

SIZE: A3

T:\GIS Projects\0133576_Anadarko_Moz_LNG\Mapping\MXD\ESIA\Chapter12\Wooded Inland LCA.mxd

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.

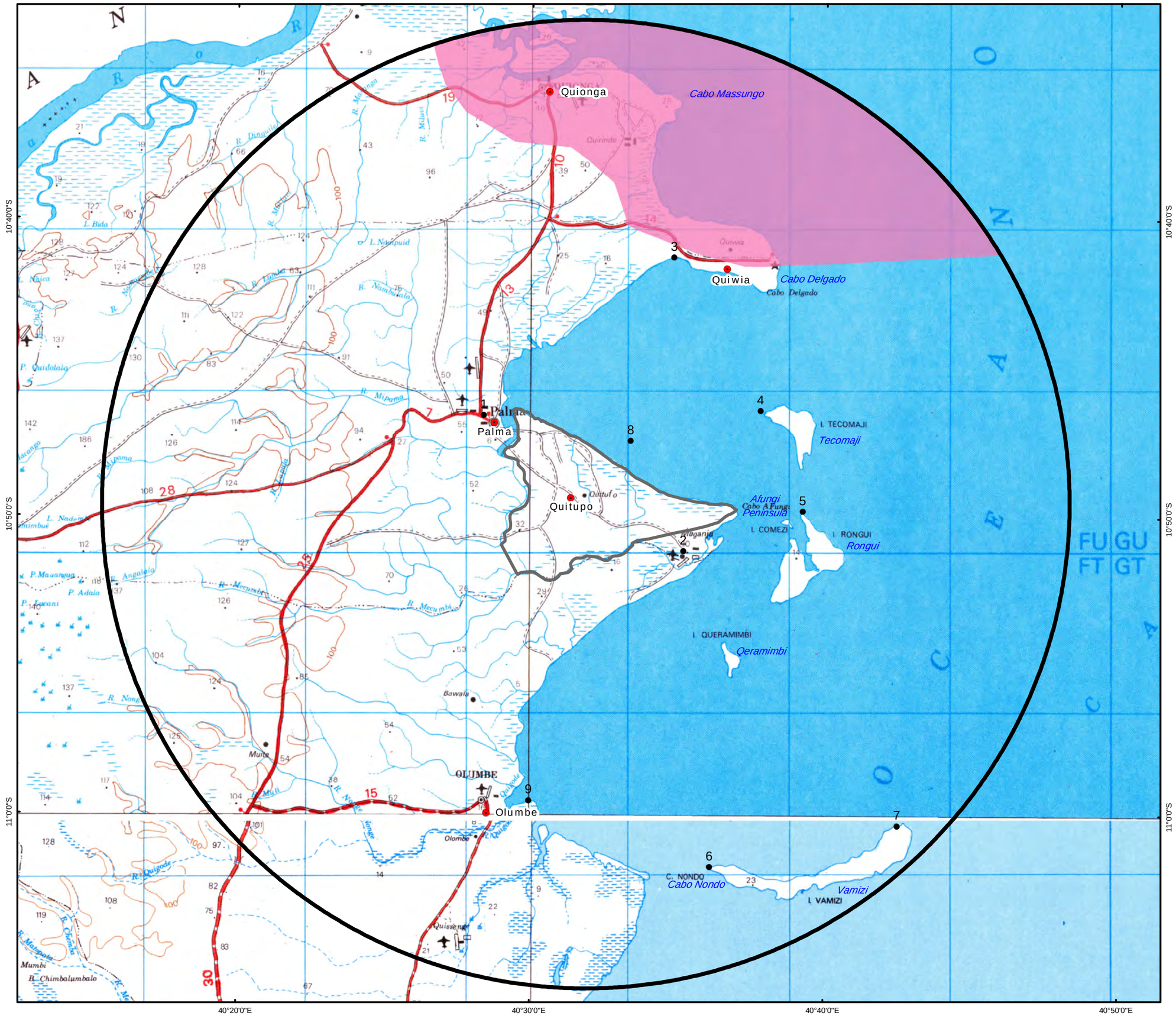
The activities associated with the Near Shore and Onshore Project will be located at least 12km away from this Seascape Unit. Taking into account the distance and temporary nature of these construction works, a Low magnitude of change will arise to this Seascape Unit, of Low sensitivity, resulting in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

REV: 0

ERM
Great Westerford Building
240 Main Road
Rondebosch, 7725
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Tel: +27 21 681 5400
Fax +27 21 686 073

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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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.

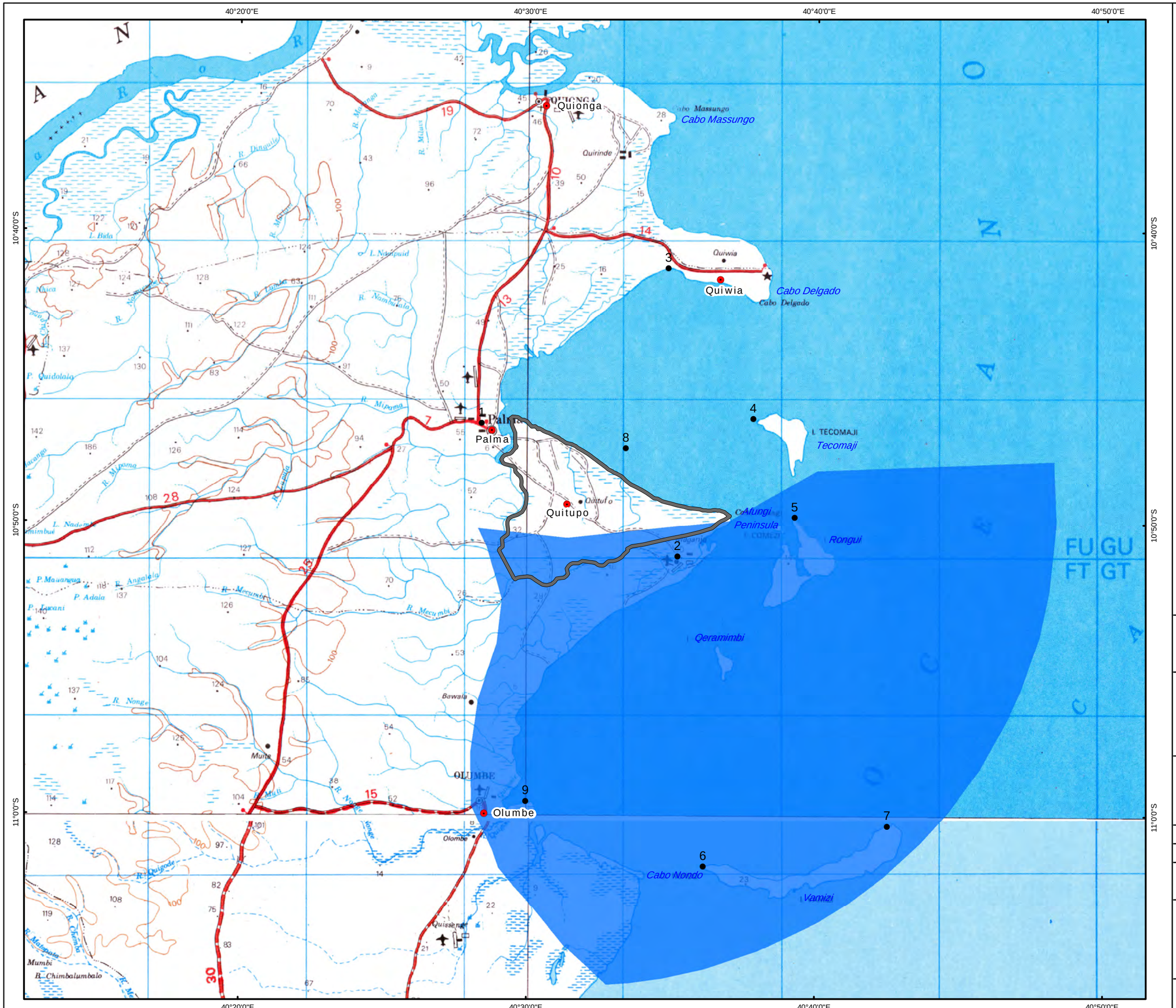
Construction

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.



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			
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 12.23 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			
Direction from site:	NNE			
View point level:	6.0m			
Photo taken:	29/1/12		ERM	Figure Existing view at Viewpoint 3 Quiwia
Horizontal field of view:	51°			
Viewing distance approx:	45cm for A3 print			
Perspective	Cylindrical			
			DATE: 1/8/12	CHECKED: EOC
			DRAWN: TMD	APPROVED: EOC
			PROJECT: LNG Mozambique	
			DRAWING:	REV: 0

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

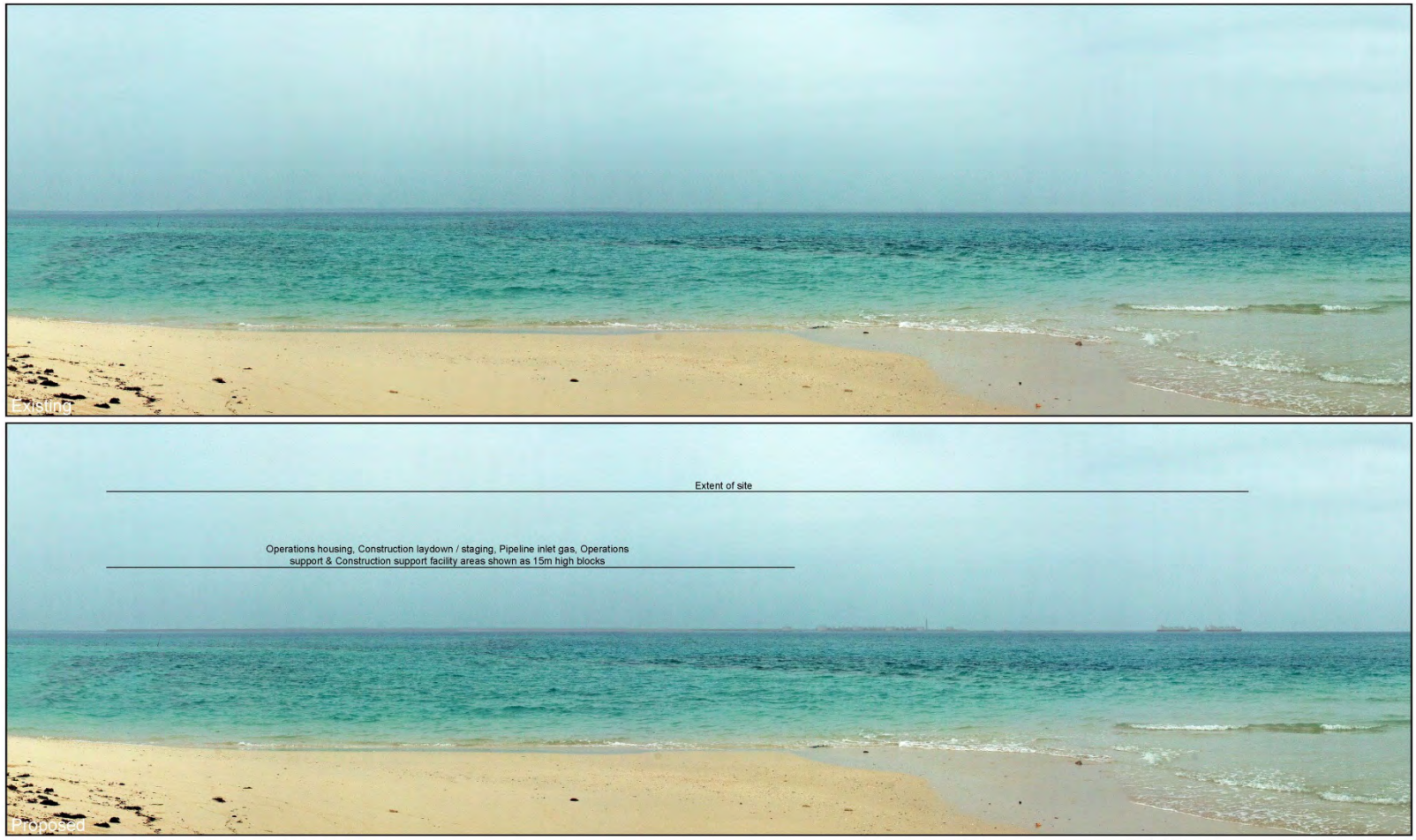
Figure 12.26 Existing View at Viewpoint 4 Tecomaji

Grid Reference:	678204 E 8808547 N		CLIENT:	SIZE: A3	Figure Existing view at Viewpoint 4 Tecomaji
Distance to site:	7.0Km				
Direction from site:	NE				
View point level:	8.7m				
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 12.27 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°			DATE: 1/8/12 | CHECKED: EOC | PROJECT:
Viewing distance approx:	45cm for A3 print			DRAWN: TMD | APPROVED: EOC | LNG Mozambique
Perspective	Cylindrical			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	Figure Existing view at Viewpoint 6 West tip of Vamisi
Distance to site:	20.0Km				
Direction from site:	S				
View point level:	4.4m				
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	CLIENT:
Distance to site:	20.0Km		SIZE: A3
Direction from site:	S		ERM
View point level:	4.4m		Figure Proposed view at Viewpoint 6 West tip of Vamisi
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		

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 14m³/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 (m³/hour)	Recommended Maximum Pumping Rates (m³/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 600m³/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 000m³/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 880m³/d sustainably. The remaining 620 – 2,120m³/d would have to be delivered by an additional 3 – 11 boreholes assuming average pumping rates of 5 – 9.2m³/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

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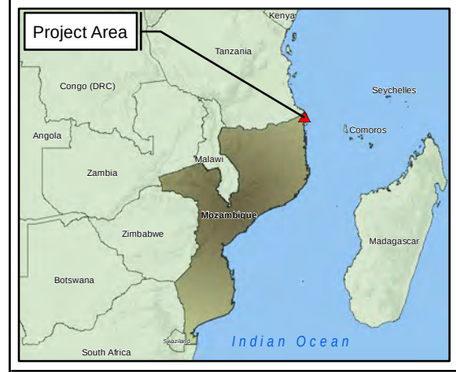
Legend

- 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:

0 500 1,000 1,500 2,000
Metres

N

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

ERM
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Impacto Projectos e Estudos Ambientais
ERM

Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
Natural Scientific Services CC, 2012.
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

Palma
Quitupo
Senga
Maganja
Palma Bay

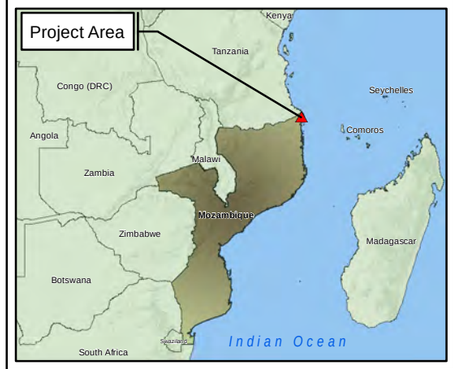
bing™

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)



MAIN MAP SCALE:

0 500 1,000 1,500 2,000

Metres

N

TITLE:

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

ERM
Great Westerford Building
240 Main Road
Rondebosch, 7725
Cape Town, SOUTH AFRICA
Tel: +27 21 681 5400
Fax +27 21 686 073

Impacto Projectos e Estudos Ambientais

ERM

Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
Natural Scientific Services CC, 2012.

SIZE: A3

T:\GIS Projects\0133576_Anadarko_Moz_LNG\Mapping\MXD\ESIA\Chapter12\Wetlands Revised OPF.mxd

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

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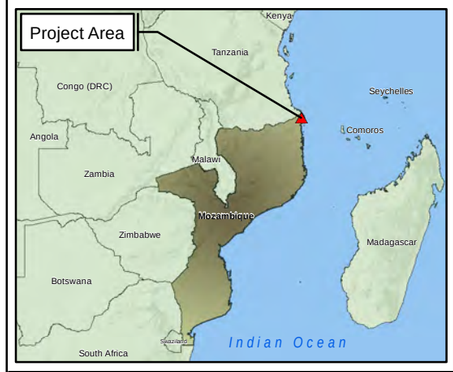
Legend

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

Vegetation Sensitivity

- Very Low
- Low
- Medium
- High
- Very High



MAIN MAP SCALE:

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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
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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.

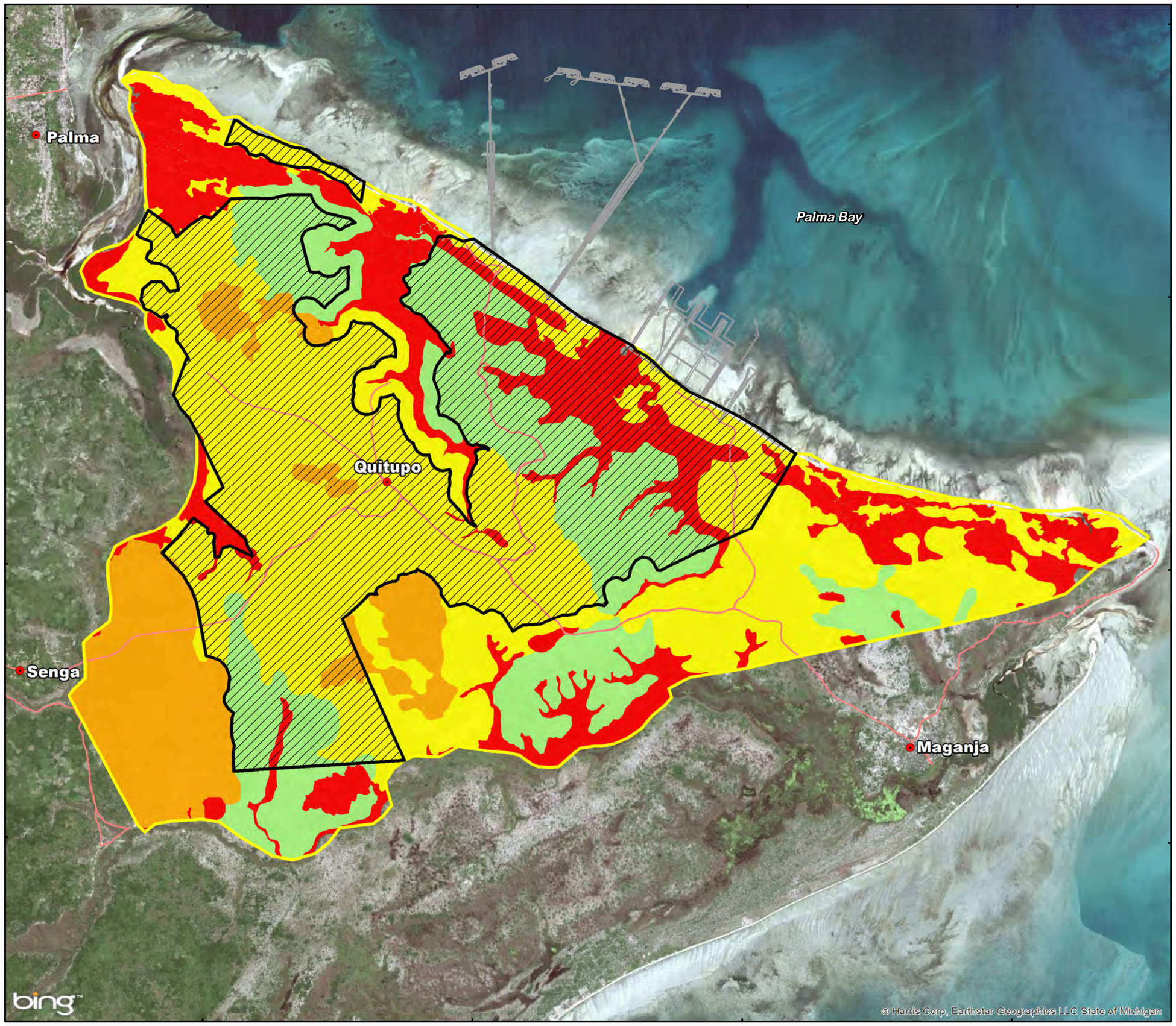
- Rehabilitate temporary-use areas using methods in accordance with the Decommissioning and Rehabilitation Plan (see *Annex F).*

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**

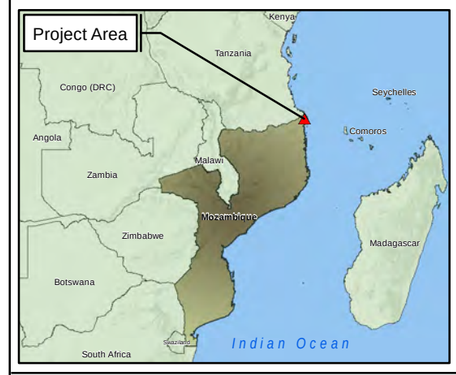


Legend

- Villages / Settlements
- Local Roads
- Nearshore Components
- Revised Project Footprint
- Afungi Project Site

Vegetation Sensitivity

- Very Low
- Low
- Medium
- High
- Very High



MAIN MAP SCALE:

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TITLE:

Figure 12.36: Reduced Impact on Sensitive Vegetation Communities - Revised Project Layout

CLIENT:

Anadarko Moçambique Área 1, Lda

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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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Quitupo

Senga

Maganja

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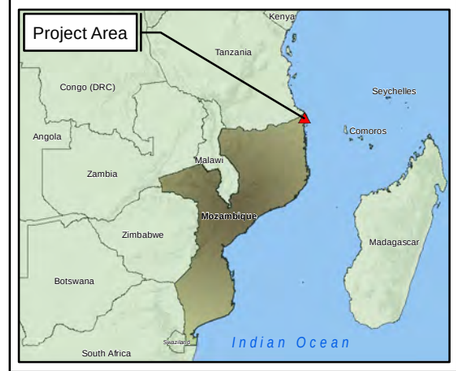
Legend

- 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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Kilometers

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TITLE:

Figure 12.37: Herpetofauna Sensitivity Map - Onshore Project Footprint Area

CLIENT:

Anadarko Moçambique Área 1, Lda

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DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
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Fax +27 21 686 073

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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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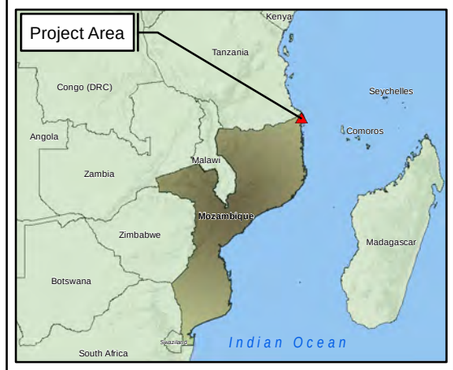
Legend

- 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

CLIENT:

Anadarko Moçambique Área 1, Lda

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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.

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

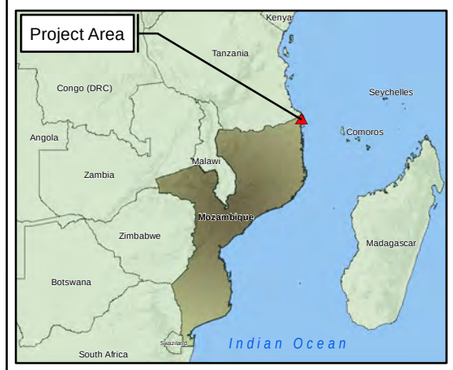
bing™

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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Kilometers

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TITLE:

Figure 12.39: Avifaunal 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: Avifaunal 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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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

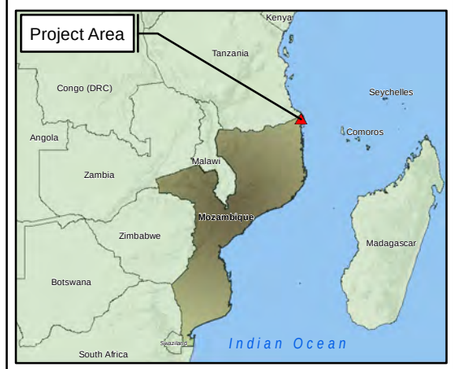
bing™

Legend

- Villages / Settlements
- Local Roads
- Nearshore Components
- Revised Project Footprint
- Afungi Project Site

Avifauna Sensitivity

- Low
- Medium
- Medium-High
- High



MAIN MAP SCALE:

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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

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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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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

Palma
Quitupo
Senga
Maganja
Palma Bay

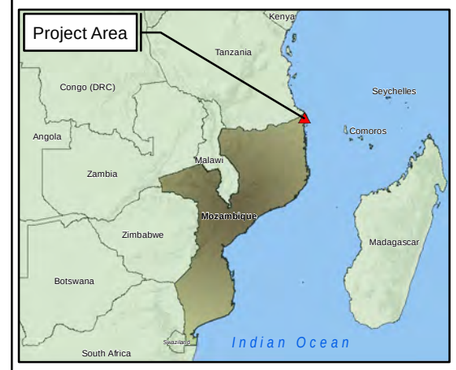
bing™

Legend

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

Mammal Sensitivity

- Low
- Medium
- High



MAIN MAP SCALE:

0 1 2 3
Kilometers

N

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

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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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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.

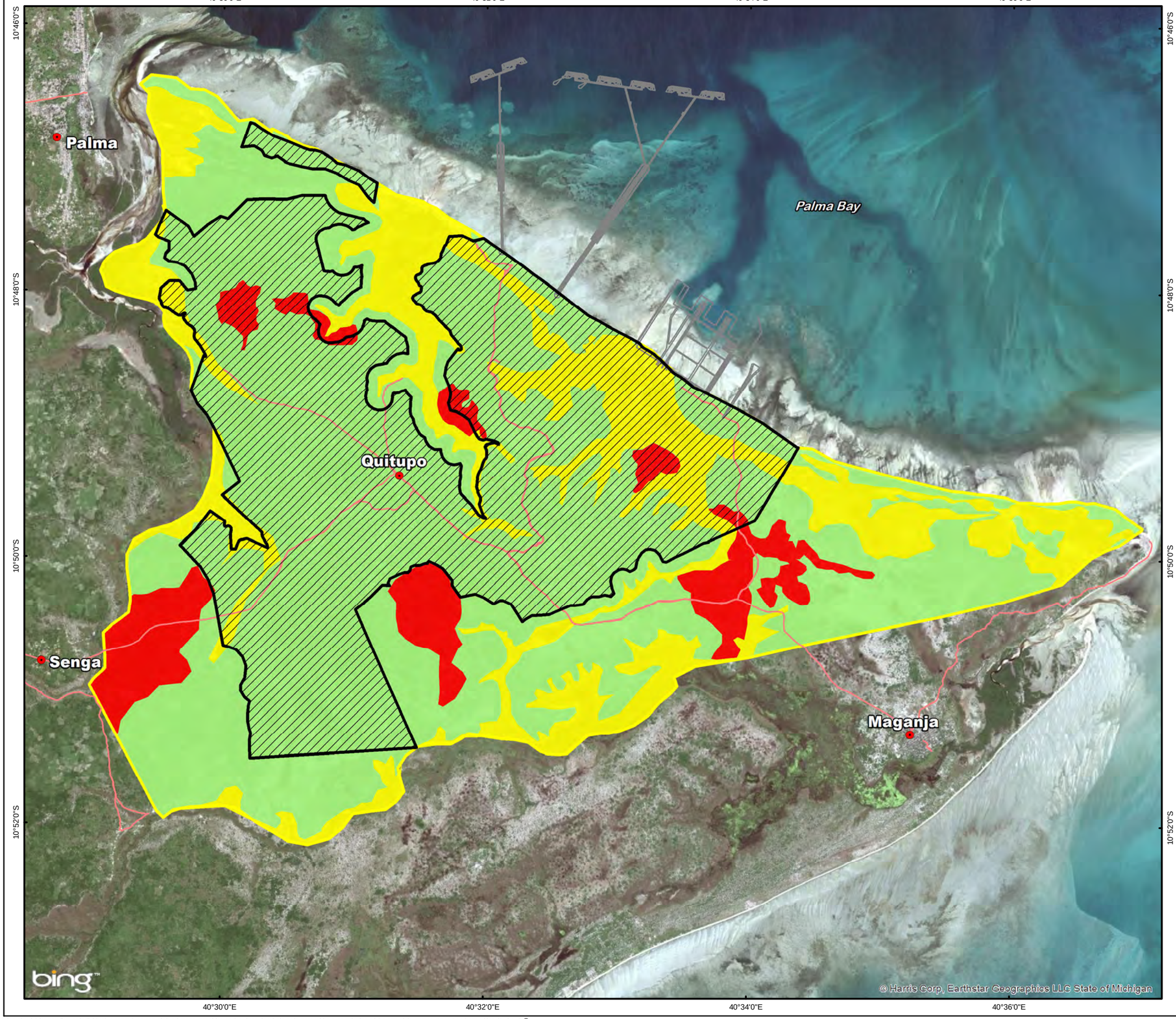
- Establish 150m buffer zones around wetlands to prevent adverse impacts. These buffer areas will be clearly demarcated to restrict the movement of construction equipment and workers into adjacent sensitive areas.

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**

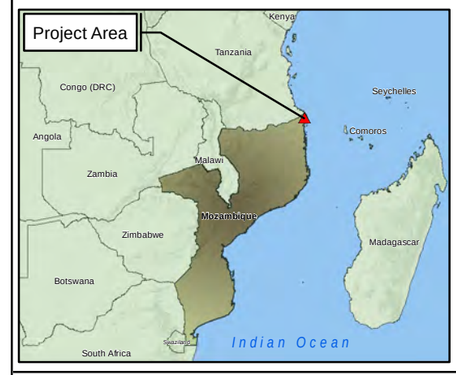


Legend

- 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

N

TITLE:

Figure 12.42: Reduced Impact on Mammals Habitat - Revised Project Layout

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: CZ	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 50 000

DRAWING: Mammal Sensitivity Revised OPF.mxd

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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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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.