ExxonMobil PNG Limited

Papua New Guinea LNG Project

Environmental Management Plan: LNG Plant and Marine Facilities

PGGP-EH-OPZZZ-000004-003

CONTENTS

TABLES

FIGURES

APPENDICES

ACRONYMS AND DEFINITIONS

ACRONYM	DESCRIPTION
µg/m^3	micrograms per cubic metre
CEPA	Conservation and Environment Protection Authority
dBA	A-weighted decibels
DEA	Diethanolamine
E&R	Environmental and Regulatory
EA	Ethanolamine
EMP	Environmental Management Plan
EMPNG	ExxonMobil PNG Limited
IESC	Independent Environmental and Social Consultant
IFC	International Finance Corporation
IUCN	International Union for Conservation of Nature
LNG	Liquefied Natural Gas
LNGP WMA	LNG Plant Waste Management Area
MDEA	Methyl diethanolamine
mg/m^3	milligrams per standard cubic metre
ng/m^3	nanograms per standard cubic metre
NTU	Nephelometric Turbidity Unit
OIMS	Operations Integrity Management System
PNG	Papua New Guinea
PNG LNG EIS	PNG LNG Project Environmental Impact Statement
PM	Particulate Matter
ppm	parts per million
SHE	Safety, Health and Environment
WHRU	Waste Heat Recovery Unit
WWTP	Wastewater Treatment Plant
WORD	**DEFINITION**
above grade	Above the surrounding ground surface
de minimis	A term used by the United States Environmental Protection Agency to describe emissions levels which are negligible and for which no conformity levels are established
grade	Gradient/slope of the surrounding surface which could be concrete, asphalt, earth etc.
receiving environment	A representative point, zone, or boundary within the natural aquatic (freshwater or marine) environment where naturally occurring physical, chemical and biological conditions should not be influenced by discharges arising from EMPNG activities and or facilities.

Corporate Separateness Notice

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PNG LNG is an integrated development that includes gas production and processing facilities, onshore and offshore pipelines and liquefaction facilities. Participating interests are affiliates of Exxon Mobil Corporation (including ExxonMobil PNG Limited as operator), Oil Search Limited, Kumul Petroleum Holdings Limited, Santos Limited, JX Nippon Oil and Gas Exploration, and Mineral Resources Development Company.

1.0 INTRODUCTION

This Environmental Management Plan: LNG Plant and Marine Facilities is a component of the Environmental and Social Management Plan for production of the Papua New Guinea Liquefied Natural Gas (PNG LNG) Project.

1.1 Scope

This Environmental Management Plan (EMP) is applicable to the LNG Plant and Marine Facilities.

The location of the LNG Plant and Marine Facilities is shown in Figure 1-1.

This EMP is not applicable to the PNG LNG Port Moresby office, which is addressed in the Environmental Management Plan: Port Moresby Office. This EMP is also not applicable to the facilities shown below, which are addressed in the Environmental Management Plan: Upstream Facilities, Infrastructure and Pipelines:

- Hides gas field wellpads (Wellpads B, C, D, E, F[1] and G)
- Angore gas field wellpads (Wellpads A and B)
- Hides Wellpad Access Road
- Angore Wellpad Access Road
- Produced Water Reinjection Well
- Hides Gas Conditioning Plant
- Hides Waste Management Facility
- Hides Vehicle Wash Facility
- Support camps
- Komo Airfield
- Hides Gathering System including the Hides Spineline
- Angore Gathering System
- HGCP-Kutubu Condensate Pipeline
- HGCP-Kutubu Condensate Pipeline Above Ground Installations
- PNG LNG Gas Pipeline (onshore/offshore)
- PNG LNG Gas Pipeline Above Ground Installations
- PNG LNG Gas Pipeline and Above Ground Installation Access Tracks.

This EMP is applicable to normal operating conditions, startup and shutdown activities, and reasonably foreseeable abnormal operating conditions and emergency situations. Where deemed necessary by EMPNG, a site-specific or scope-specific Environmental Management Plan may be developed as an addendum to this EMP. For example, construction of new facilities that will introduce additional environmental aspects or potentially increase existing environmental impacts. In these instances, additional mitigation measures and commitments outlined in the PNG LNG Project Environmental Impact Statement (PNG LNG EIS; EMPNG as Esso Highlands Limited, 2009) that are not specifically included in this EMP, may be applicable.

This EMP is applicable to the operations and activities of ExxonMobil PNG Limited (EMPNG) including its contractors and subcontractors. Where deemed necessary by EMPNG, contractors and subcontractors may be required to develop and implement a site-specific or scope-specific Environmental Management Plan.

This EMP is supported by and makes reference to a number of procedures and other working documents including protocols and method statements, which are internal EMPNG documents developed on the basis of standard industry methods, where applicable.

[1] Wellpad F refers to the wellpad where the Hide 5 deep producing well was installed. This wellpad was originally called Hides 5 wellpad and is different to the original Wellpad F referred to in the PNG LNG Project Environmental Impact Statement (Esso Highlands Limited, 2009).

1.2 Objectives

This EMP describes the measures in place to manage environmental aspects pertaining to the LNG Plant and Marine Facilities and implement applicable legal and other requirements. Specific environmental management objectives are outlined in Section 4.0.

Figure 1-1: LNG Plant and Marine Facilities location map

2.0 LEGAL AND OTHER REQUIREMENTS

Details of applicable legal and other requirements are provided below.

2.1 Laws and regulations of Papua New Guinea

Key laws and regulations of Papua New Guinea relevant to this EMP are as follows including associated amendments:

- *Climate Change (Management) Act 2015*
- *Conservation and Environment Protection Authority (Environment Management Fee) 2015*
- *Environment Act 2000*
- *Environment (Prescribed Activities) Regulation 2002*
- *Environment (Permits) Regulation 2002*
- *Environment (Water Quality Criteria) Regulation 2002*
- *Fauna (Protection and Control) Act 1966*
- *International Trade (Fauna and Flora) Act 1979 (Chapter 391)*
- *The Environmental Code of Practice for Sanitary Landfill Sites, Papua New Guinea (The Office of Environment and Conservation, 2001)*
- *Customs (Prohibited Imports) Regulation 1973*
- *Explosives Act 1953 and Explosives Regulation 2002*
- *Inflammable Liquid Act 1953 and Inflammable Liquid Regulation 1968*
- *Public Health Act 1973*
- *Public Health (Sanitation and General) Regulation 1973*
- *Public Health (Sewerage) Regulation 1973*
- *National Water Supply and Sanitation Act 2016*
- *National Cultural Property (Preservation) Act 1965.*

Specific requirements of these laws and regulations are discussed, where relevant, in this EMP.

2.2 Environment Permit

The primary legislation governing environmental matters in Papua New Guinea is the *Environment Act 2000*. The *Environment Act 2000* is supported by the *Environment (Prescribed Activities) Regulation 2002*.

An Environment Permit is required for PNG LNG pursuant to the *Environment (Prescribed Activities) Regulation 2002*. Environment Permit EP-L3 (210) (the Environment Permit) was issued by the Papua New Guinea Conservation and Environment Protection Authority (CEPA), formerly known as the Department of Environment and Conservation, on 9 September 2009. Amendments to the Environment Permit were issued on 29 October 2009, 22 October 2012 and 12 October 2015.

This EMP, together with the Environmental Management Plan: Upstream Facilities, Infrastructure and Pipelines, constitutes the Project Environmental Management Plan for production, referred to in the Environment Permit. Specific requirements and conditions of the Environment Permit are discussed where relevant in this EMP.

The PNG LNG Port Moresby office operates under a site-specific Environment Permit and is not discussed further in this EMP.

2.3 Operations Integrity Management System

ExxonMobil and its affiliates meet policy commitments and control operations integrity risks through the Operations Integrity Management System (OIMS).

OIMS establishes common worldwide expectations for addressing inherent risks. It addresses all aspects, including security, which can impact safety, health and environmental performance.

OIMS is certified as equivalent to *ISO 14001:2004 Environmental management systems - Requirements with guidance for use (International Organization for Standardization, 2004)* by Lloyd's Register. Certification is periodically reviewed by Lloyds Register and maintained current.

Several OIMS Systems are relevant to this EMP. Specific OIMS requirements are discussed where relevant, throughout this EMP.

2.4 Lender Group requirements

Debt financing was secured for PNG LNG through various Export Credit Agencies and commercial banks. The Export Credit Agencies and commercial banks, collectively referred to in this document as the Lender Group, apply the International Finance Corporation's (IFC's) Performance Standards on Social and Environmental Sustainability (IFC, 2006), referred to as the 'Performance Standards'; and the International Finance Corporation's Guidance Notes: Performance Standards on Social and Environmental Sustainability (IFC, 2007), referred to as the 'Guidance Notes' and relevant guidelines.

Performance Standards, Guidance Notes and guidelines applicable to this EMP are:

- Performance Standard 1: Social and Environmental Assessment and Management Systems
- Performance Standard 3: Pollution Prevention and Abatement
- Performance Standard 4: Community Health, Safety and Security
- Performance Standard 6: Biodiversity Conservation and Sustainable Natural Resource Management
- Performance Standard 8: Cultural Heritage
- Guidance Note 1: Social and Environmental Assessment and Management Systems
- Guidance Note 3: Pollution Prevention and Abatement
- Guidance Note 4: Community Health, Safety and Security
- Guidance Note 6: Biodiversity Conservation and Sustainable Natural Resource Management
- Guidance Note 8: Cultural Heritage
- Environmental, Health, and Safety General Guidelines (IFC, 2007)
- Environmental, Health, and Safety Guidelines for Waste Management Facilities (IFC, 2007)
- Environmental, Health, and Safety Guidelines for Liquefied Natural Gas (LNG) Facilities (IFC, 2007)
- Environmental, Health, and Safety Guidelines for Onshore Oil and Gas Development (IFC, 2007)
- Environmental, Health, and Safety Guidelines for Offshore Oil and Gas Development (IFC, 2007).

Specific requirements of the above listed Performance Standards, Guidance Notes and guidelines are discussed where relevant in this EMP.

3.0 ORGANISATION

OIMS System 1-1 Management Leadership, Commitment and Accountability requires the allocation of sufficient resources for the implementation and continuous improvement of operations integrity, along with the establishment of OIMS-related roles and responsibilities.

An overview of EMPNG's organisation as relevant to environmental management during production is provided in this section.

3.1 OIMS Management Steering Committee

Pursuant to OIMS System 1-1 Management Leadership, Commitment and Accountability, EMPNG managers and supervisors will demonstrate commitment and accountability to operations integrity, including the implementation of this EMP, through active participation.

As such, EMPNG will charter an OIMS Management Steering Committee to provide management perspective, set expectations and allocate resources for the implementation and continuous improvement of operations integrity within the organisation.

The OIMS Management Steering Committee will steward OIMS goals and objectives, including goals and objectives pertaining to environmental management as set out in this EMP.

3.2 Environmental and Regulatory organisation

EMPNG's Environmental and Regulatory (E&R) group is allocated primary responsibility for the implementation and ongoing oversight of this EMP. The E&R group forms part of the Safety, Health and Environment (SHE) department.

An outline of EMPNG's SHE department is shown in Figure 3-1, but it is recognised that the organisation will be adapted as required to meet conditions and operational needs.

In addition to the SHE department, other EMPNG production and maintenance personnel have defined roles and responsibilities with respect to this EMP. Roles and responsibilities of key personnel are described in Section 21.0. Competency and training is discussed in Section 22.0.

EMPNG will retain third party consultants and other specialist organisations and individuals to support implementation of this EMP.

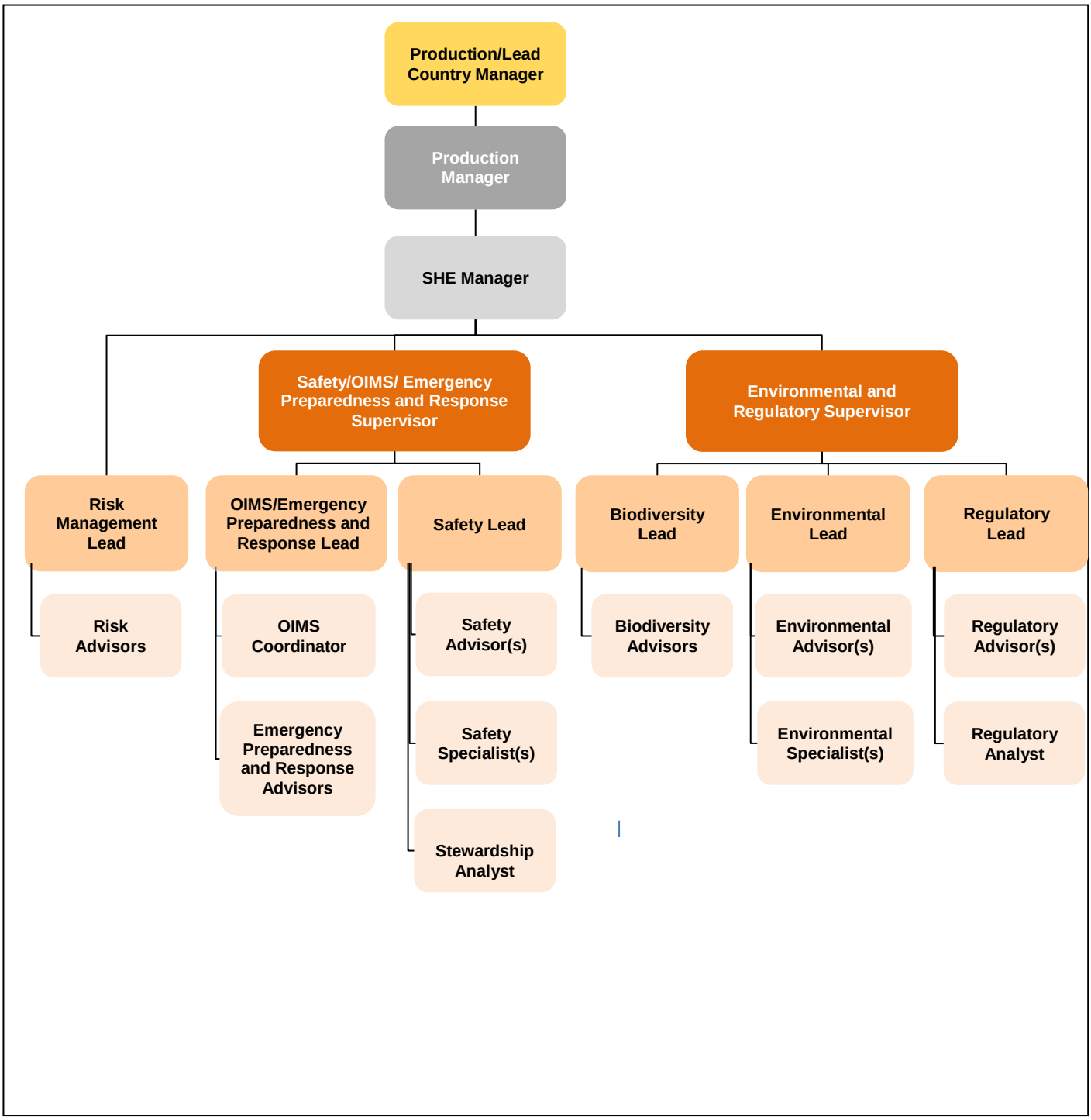

Figure 3-1: Safety, Health and Environment department

4.0 ENVIRONMENTAL ASSESSMENT AND MANAGEMENT

OIMS System 6-5 Environmental Management requires the identification of environmental aspects. It also requires that environmental management is fully integrated into the organisation's business planning and that environmental performance is tracked and stewarded to meet performance goals. The physical, biophysical and socioeconomic setting and context is summarised below, followed by a description of the process of identification and evaluation of environmental aspects relevant to production. A description of the process for environmental management and establishment of mitigation measures set out in this EMP is also provided for in this section.

4.1 Environmental and social overview

An overview of key environmental and social features associated with the LNG Plant and Marine Facilities is outlined below. Further details are provided in the PNG LNG Project Environmental Impact Statement (PNG LNG EIS) (EMPNG as Esso Highlands Limited, 2009).

4.1.1 Bio-physical environment overview

The only intact, original vegetation remaining on the LNG Plant site is a strip of mangroves along the coast and at the mouth of the Vaihua River. Saltpans are present between the mangroves and cleared agricultural areas. The cleared areas are covered in pasture grasses and herbaceous plants (including both non-invasive and invasive weed species). Some isolated patches of Pandanus and low trees on shallow drainage lines exist near the Vaihua River.

Key biological aspects at the LNG Plant site include on the offshore fringing reef, scattered coral reef bommies and seagrass beds; the coastal mangrove strip; and the potential presence of sensitive near-shore marine species, such as dugongs and turtles.

4.1.2 Biophysical environment and Social overview

The closest villages to the LNG Plant (known collectively as the LNG Plant site villages), are Papa and Lea Lea to the north and Boera and Porebada to the south. They lie within the three-nautical mile coastal zone where all fishing is restricted to customary fisheries. No commercial vessels are permitted to operate in this area.

The villages are inhabited by the Motu-Koita speaking people, who extend from Gaba Gaba (50 kilometres south-east of Port Moresby) to Manumanu (about 50 kilometres north-west of Port Moresby). Population density of the area is around ten persons per square kilometre.

Coastal people in the region are engaged in minor sales of betelnut, coconut, fish and other fresh food, and also derive income from wage employment and operating local small businesses. Sweet potato, banana and cassava are also important staple crops. Land potential is relatively poor due to a combination of poor soils, seasonal inundation and land degradation.

Artisanal fisheries provide regular supplies of fresh reef fish to Port Moresby and LNG Plant site villages.

4.2 Environmental impact assessment

Environmental aspects and impacts associated with production were initially identified and evaluated as part of the impact assessment conducted for the PNG LNG EIS (EMPNG as Esso Highlands Limited, 2009). The PNG LNG EIS was finalised and submitted to CEPA in January 2009 as the statutory basis for environmental and social assessment pursuant to Section 50 of the *Environment Act 2000.*

The impact assessment presented in the PNG LNG EIS is based on an impact significance assessment process. For aspects associated with terrestrial biodiversity, surface water and

groundwater, soils, air quality and noise, the impact significance is expressed in a matrix of the value (or sensitivity) of a receptor and the magnitude of the impact. In the case of cultural heritage, the impact significance is presented using a matrix of valence (positive or negative), nature of impact (direct, indirect or cumulative), duration, extent, magnitude and likelihood. In both cases, the impact significance assessment process accounted for a range of factors, including the nature (positive, negative, direct or indirect) extent, duration and severity.

The PNG LNG EIS includes environmental management and mitigation measures designed to address potential environmental impacts during production. Each mitigation measure has a unique reference code. Mitigation measures applicable to the LNG Plant and Marine Facilities are within the scope of this EMP and are shown in Appendix 1.

Further details are provided in the PNG LNG EIS available at www.pnglng.com.

4.3 Environmental aspects assessment

An environmental aspect is an activity, product or service that interacts with the environment and may have beneficial, adverse, and/or neutral effects. OIMS System 6-5 Environmental Management requires that environmental aspects are evaluated using an Environmental Aspects Assessment process, consistent with requirements of *ISO 14001:2004 Environmental management systems - Requirements with guidance for use (International Organization for Standardization, 2004)*. In accordance with these requirements, EMPNG undertook an Environmental Aspects Assessment for production operations, and is reviewed and updated on a regular basis. The Environmental Aspects Assessment forms the basis for the management of environmental aspects as set out in this EMP.

A summary of the environmental aspects applicable to the LNG Plant and Marine Facilities, the associated risk scenarios and a reference to the section of this EMP where these aspects and scenarios are addressed is shown in Table 4-1.

4.4 Environmental management and mitigation

This EMP describes management and mitigation measures in place to address the identified environmental aspects and to achieve the environmental management objectives shown in Table 4-2. Mitigation measures include design controls (controls that are inherent to facilities and infrastructure) and operational controls (controls implemented by EMPNG and other personnel).

Table 4-1: Overview of environmental aspects and risk scenarios

PERFORMANCE STANDARD THEME	ENVIRONMENTAL ASPECT CATEGORY	ENVIRONMENTAL ASPECT OVERVIEW	RISK SCENARIO OVERVIEW	EMP SECTION REFERENCE
Performance Standard 3: Pollution Prevention and Abatement Pollution Prevention, Resource Conservation and Energy Efficiency	Emissions and releases to air	Compressor gas turbine emissions	Risk of health and ecological impacts associated with release of pollutants to air	Section 6.0
		Main power generator emissions		
		Flare emissions (including wet and dry flares, and tankage flare)		
		Regeneration gas furnace emissions		
		Pressure safety valve emissions		
		Incinerator emissions		
		Atmospheric vent emissions		
		Diesel engine emissions		
		Fugitive emissions		
		Dust		
		Light		
		Ambient air quality	Risk of health and ecological impacts associated with ground-level pollutants	Section 7.0
		Noise	Risk of health and ecological impacts associated with exposure to noise	Section 8.0
	Discharges and releases to water	Stormwater discharges	Risk of health and ecological impacts associated with the release of pollutants to surface water and groundwater	Section 9.0
		Sanitary wastewater discharges		
		Desalination plant brine discharges		
		Landfill leachate discharges		
		Oily wastewater treatment system discharges		
		Retention pond discharges		
	Waste	Waste avoidance and minimisation		Section 12.0

PERFORMANCE STANDARD THEME	ENVIRONMENTAL ASPECT CATEGORY	ENVIRONMENTAL ASPECT OVERVIEW	RISK SCENARIO OVERVIEW	EMP SECTION REFERENCE
Performance Standard 3: Pollution Prevention and Abatement Waste		Waste collection	Risk of health and ecological impacts associated with release of pollutants in waste	
		Waste storage and transfer		
		Waste reuse, recycling and recovery		
		Waste treatment and disposal		
		Waste tracking and documentation		
Performance Standard 3: Pollution Prevention and Abatement Hazardous Materials	Hazardous materials	Prohibited substances	Risk of health and ecological impacts associated with the transport, storage, use and disposal of hazardous materials	Section 11.0
		Avoidance of hazardous materials		
		Transportation of hazardous materials		
		Storage and use of hazardous materials		
		Disposal of hazardous materials		
Performance Standard 3: Pollution Prevention and Abatement Emergency Preparedness and Response	Releases to soil and water (spills)	Transport of fuel and chemicals	Risk of health and ecological impacts resulting from a spill or release of pollutants (oil or chemicals) to the environment	Section 10.0
		Fuel storage and transfer		
		Chemical storage and transfer		
		Spill response		
		Site remediation		
Performance Standard 3: Pollution Prevention and Abatement Greenhouse Gas Emissions	Emissions and releases to air (greenhouse gases)	Emissions of greenhouse gases (including those from construction equipment and vehicles)	Contribution to climate related effects associated with the release of greenhouse gases	Section 6.0
Performance Standard 3: Pollution Prevention and Abatement Pesticide Use and Management	Chemical usage	Use of pesticides	Risk of health and ecological impacts associated with the use of pesticides and herbicides	Section 11.0
		Use of herbicides		

PERFORMANCE STANDARD THEME	ENVIRONMENTAL ASPECT CATEGORY	ENVIRONMENTAL ASPECT OVERVIEW	RISK SCENARIO OVERVIEW	EMP SECTION REFERENCE
Performance Standard 6: Biodiversity Conservation and Sustainable Natural Resource Management	Land and vegetation disturbance	Erosion and sediment	Risk of impacts to biodiversity values and water quality associated with erosion and sedimentation	Section 13.0
		Reinstatement and regeneration	Risk of impacts to biodiversity values associated with failure of reinstatement works and poor vegetation succession	Section 14.0
		Invasive species (priority weeds and pests)	Risk of impacts to biodiversity values and subsistence and commercial agriculture associated with the introduction and/or spread of invasive species	Section 15.0
		Ecological sensitivities and focal habitats	Risk of impacts to habitats, specific habitat features and species of ecological importance and other ecological sensitivities	Section 16.0
	Other services	Use of aggregate and quarry material	Risk of impacts to biodiversity values and community safety associated with the procurement of aggregate and quarry material	Section 11.0
		Use of timber and wood products	Risk of impacts to biodiversity values associated with procurement of timber and wood products	Section 11.0
Performance Standard 8: Cultural Heritage	Cultural heritage	Management of known and unknown archaeological and oral tradition sites	Risk of impacts to cultural heritage	Section 17.0

Table 4-2: Environmental management objectives

ENVIRONMENTAL ASPECT	OBJECTIVE
Emissions to air and ambient air quality	• Avoid significant impacts associated with the release of pollutants to the atmosphere • Meet applicable emissions and air quality criteria
Noise	• Avoid significant noise and vibration impacts to community and fauna • Meet applicable noise criteria
Discharges to water and water quality	• Avoid significant impacts associated with the release of pollutants to surface water and groundwater • Meet applicable discharge criteria
Spill prevention and response	• Prevent spills of hydrocarbons and chemicals • Respond quickly and effectively to spills should they occur
Materials management	• Avoid significant impacts associated with the procurement and use of raw materials • Use materials which are less hazardous or otherwise preferable from an environmental perspective, where practical
Waste	• Apply the waste management hierarchy • Manage and dispose of waste at EMPNG facilities and approved third party facilities only
Erosion and sediment control	• Control significant erosion and prevent significant sedimentation of surface waters
Reinstatement and regeneration	• Establish and maintain stable landforms in areas disturbed as a result of construction type activities • Promote regeneration of vegetation in disturbed areas that are no longer required for production • Achieve established benchmarks for regeneration areas
Invasive species	• Prevent priority invasive species (priority weeds and/or pests) from entering or establishing in the LNG Plant and Marine Facilities area • Contain priority invasive species (priority weeds and/or pests) already established in the LNG Plant and Marine Facilities area
Ecology	• Avoid impacts to specific features of ecological importance including specific fauna habitats (e.g. turtle nesting sites)
Cultural heritage	• Avoid impacts to known cultural heritage sites, including archaeological and oral tradition sites • Manage cultural heritage sites in consultation with landowners

5.0 DESCRIPTION OF FACILITIES

An overview and description of the LNG Plant and Marine Facilities is provided in this section.

5.1 LNG Plant and Marine Facilities overview

The LNG Plant is located in the Central Province, approximately 20 kilometres northwest of Port Moresby, between the coastal settlements of Boera and Papa. It occupies three separate lease areas: Portion 2456 (onshore), Portion 2457 (coastal strip) and Portion 2458 (offshore).

Inlet feed gas flows into the LNG Plant which has the capacity to produce in excess of 7.4 million tonnes of LNG per year. As part of the fractionation system, condensate is also produced for sale. In addition to the sale of hydrocarbon products, PNG LNG also uses gas to generate electricity to supply the Port Moresby's electricity grid and provides fuel gas to third party power generators.

The Marine Facilities include a trestle jetty, LNG export berth, condensate export berth and tug landing area; and accommodates the loading of LNG carriers in the size range of 125,000 to 220,000 cubic metres and condensate tankers of 7000 dead weight tonnes. Diagrams of the LNG Plant and Marine Facilities are shown in Figure 5-1 and Figure 5-2 respectively.

The main processing facilities and utility systems are described below.

5.2 Inlet receiving and acid gas removal

High-pressure feed gas from the PNG LNG Gas Pipeline is delivered to the inlet receiving facilities, which include separation of any entrained liquids and heating to prevent formation of hydrates. Following pressure reduction via inlet pressure control valves, the gas is metered and routed to the acid gas removal unit for the removal of carbon dioxide to prevent carbon dioxide solidification and plugging of equipment during liquefaction.

5.3 Dehydration and mercury removal

The treated, water saturated gas from the acid gas removal unit is dehydrated using a combination of high level refrigeration, which removes about half the water, and a fixed-bed molecular sieve system, which removes the remaining water. The molecular sieve dries the gas to avoid freezing and formation of hydrates (crystals which may form in the presence of water under certain conditions and may cause line plugging) during liquefaction. Gas leaving the molecular sieves passes through a mercury guard bed to remove any mercury and prevent corrosion of aluminium equipment. The dry gas is then filtered to remove entrained dust.

5.4 Refrigeration, fractionation and liquefaction

The liquefaction process uses proprietary licensed technology to liquefy the gas. Various refrigerants are used to chill and liquefy the gas after removal of heavier hydrocarbons. Heavier hydrocarbons are removed to prevent solids from plugging equipment due to freezing. These heavier hydrocarbons are then fractionated, blended and consumed as fuel gas. Condensate recovered in the fractionation system is vapour-pressure stabilised prior to storage.

5.5 LNG and condensate storage

LNG is stored in two single containment tanks of 160,000 cubic metres per tank. Condensate recovered in the fractionation system is stored in two 11,600-cubic metre capacity floating roof storage tanks.

5.6 Utilities

A number of utilities support the LNG Plant and Marine Facilities including dry and wet flare systems; hot oil system; closed and open drain systems; refrigerant storage; fuel gas system; main power generation; essential power generation; electrical system; diesel storage and

distribution system; instrument and utility air system; nitrogen system; firewater system; utility water storage and distribution; potable water system; wastewater treatment systems; and effluent handling system. Further information is provided about these utilities where relevant in this EMP.

5.7 Marine Facilities

Marine Facilities include a combined LNG and condensate vessel berth, with associated mooring systems, cargo transfer system, monitoring, controls and emergency shutdown systems.

The terminal does not supply the vessels with bunkers or water; nor does it provide storage facilities. A small boat wharf is provided close to the head of the trestle to accommodate support vessels. These multi-purpose support vessels provide security escort services, mooring line assistance, man-overboard rescue and jetty evacuation and can also be used to deploy spill containment and response equipment.

No fixed refuelling capability is provided for the boats. Shore power for the boats is available for lighting and other light electrical loads.

The Marine Facilities are staffed by security personnel and equipped to allow security surveillance of the berth and monitoring of the berth operations and equipment.

Figure 5-1: LNG Plant layout

Figure 5-2: Marine Facilities layout

6.0 EMISSIONS TO AIR

6.1 Introduction

EMPNG's objectives are to avoid significant impacts associated with the release of pollutants to air and meet applicable emissions and air quality criteria.

Information relevant to emissions to air during production including a description of emission sources, applicable emissions criteria/guideline values and relevant design and operational controls, is provided in this section.

Operation of the facilities within the scope of this EMP gives rise to non-polluting and polluting emissions to air. Only polluting emissions are discussed herein. Non-polluting emissions, such as nitrogen, oxygen, and water are not addressed.

Emissions from mobile sources (including vehicles) is not addressed below, however fuel use in mobile sources is recorded and polluting emissions from fuel use are monitored and reported. In addition, equipment is serviced regularly and low sulphur diesel will be used in the LNGP Diesel System where commercially available and not cost prohibitive.

Ambient air quality is discussed in Section 7.0.

Provisions for emissions monitoring are set out in Section 18.0.

A summary of emissions to air is provided in Appendix 2.

6.2 Emission sources

Emission sources at the LNG Plant and Marine Facilities, including continuous and intermittent sources during normal and abnormal operating conditions, are listed in Table 6-1.

The location of each emission source is shown in Figure 6-1, followed by a description of each emission source, applicable emissions criteria and control measures, including design and operational controls.

Several sources direct gas to the flare systems and some examples of these are given in Table 6-1.

Table 6-1: LNG Plant emission sources

SOURCE	EMISSION POINT REFERENCE	TYPE
LNG Train 1 Propane Refrigerant Compressor Gas Turbine Unit 1	LNGP-A1	Continuous
LNG Train 1 Propane Refrigerant Compressor Gas Turbine Unit 2	LNGP-A2	Continuous
LNG Train 2 Propane Refrigerant Compressor Gas Turbine Unit 1	LNGP-A3	Continuous
LNG Train 2 Propane Refrigerant Compressor Gas Turbine Unit 2	LNGP-A4	Continuous
LNG Train 1 Mixed Refrigerant Compressor Gas Turbine Unit 1	LNGP-A5	Continuous
LNG Train 1 Mixed Refrigerant Compressor Gas Turbine Unit 2	LNGP-A6	Continuous
LNG Train 1 Mixed Refrigerant Compressor Gas Turbine Unit 3	LNGP-A7	Continuous
LNG Train 2 Mixed Refrigerant Compressor Gas Turbine Unit 1	LNGP-A8	Continuous
LNG Train 2 Mixed Refrigerant Compressor Gas Turbine Unit 2	LNGP-A9	Continuous
LNG Train 2 Mixed Refrigerant Compressor Gas Turbine Unit 3	LNGP-A10	Continuous
Gas Turbine Main Power Generator 1	LNGP-A11	Continuous
Gas Turbine Main Power Generator 2	LNGP-A12	Continuous
Gas Turbine Main Power Generator 3	LNGP-A13	Continuous
Gas Turbine Main Power Generator 4	LNGP-A14	Continuous

SOURCE	EMISSION POINT REFERENCE	TYPE
Gas Turbine Main Power Generator 5	LNGP-A15	Continuous
Gas Turbine Main Power Generator 6	LNGP-A16	Continuous
Gas Turbine Main Power Generator 7	LNGP-A17	Intermittent
LNG Train 1 Regeneration Gas Furnace	LNGP-A18	Continuous
LNG Train 2 Regeneration Gas Furnace	LNGP-A19	Continuous
Regeneration Furnace (Common)	LNGP-A20	Intermittent
Hot Oil System Furnace	LNGP-A21	Startup
Wet Flare Stack (Purge and Pilot Gas)	LNGP-A22	Continuous
Wet Flare Stack	LNGP-A23	Pressure relief
Dry Flare Stack (Purge and Pilot Gas)	LNGP-A24	Continuous
Dry Flare Stack	LNGP-A25	Pressure relief
Tankage Flare (Purge and Pilot Gas)	LNGP-A26	Continuous
Tankage Flare	LNGP-A27	Pressure relief
Process Waste Incinerator	LNGP-A28	Intermittent
General Waste Incinerator	LNGP-A42	Intermittent
Essential Services Generator 1	LNGP-A29	Intermittent
Essential Services Generator 2	LNGP-A30	Intermittent
Essential Services Generator 3	LNGP-A31	Intermittent
Diesel Firewater Pump Engine	LNGP-A32	Intermittent
Diesel Sea Firewater Pump Engine	LNGP-A33	Intermittent
Amine Regeneration Acid Gas/Acid Gas Removal Unit, Vent 1	LNGP-A34	Continuous
Amine Regeneration Acid Gas/Acid Gas Removal Unit, Vent 2	LNGP-A35	Continuous
Diesel Storage Tank Atmospheric Vent	LNGP-A36	Continuous
Diesel Firewater Tank Atmospheric Vent	LNGP-A37	Continuous
Diesel Sea Firewater Tank Atmospheric Vent 1	LNGP-A43	Continuous
Diesel Sea Firewater Tank Atmospheric Vent 2	LNGP-A44	Continuous
Corrosion Inhibitor Tank Atmospheric Vent	LNGP-A38	Continuous
LNG Storage Tank Pressure Safety Valves	LNGP-A39	Pressure relief
Condensate Storage Tank Pressure Safety Valves	LNGP-A40	Pressure relief
Amine Regeneration Column Pressure Safety Valves	LNGP-A41	Pressure relief
Note: LNGP = LNG Plant		

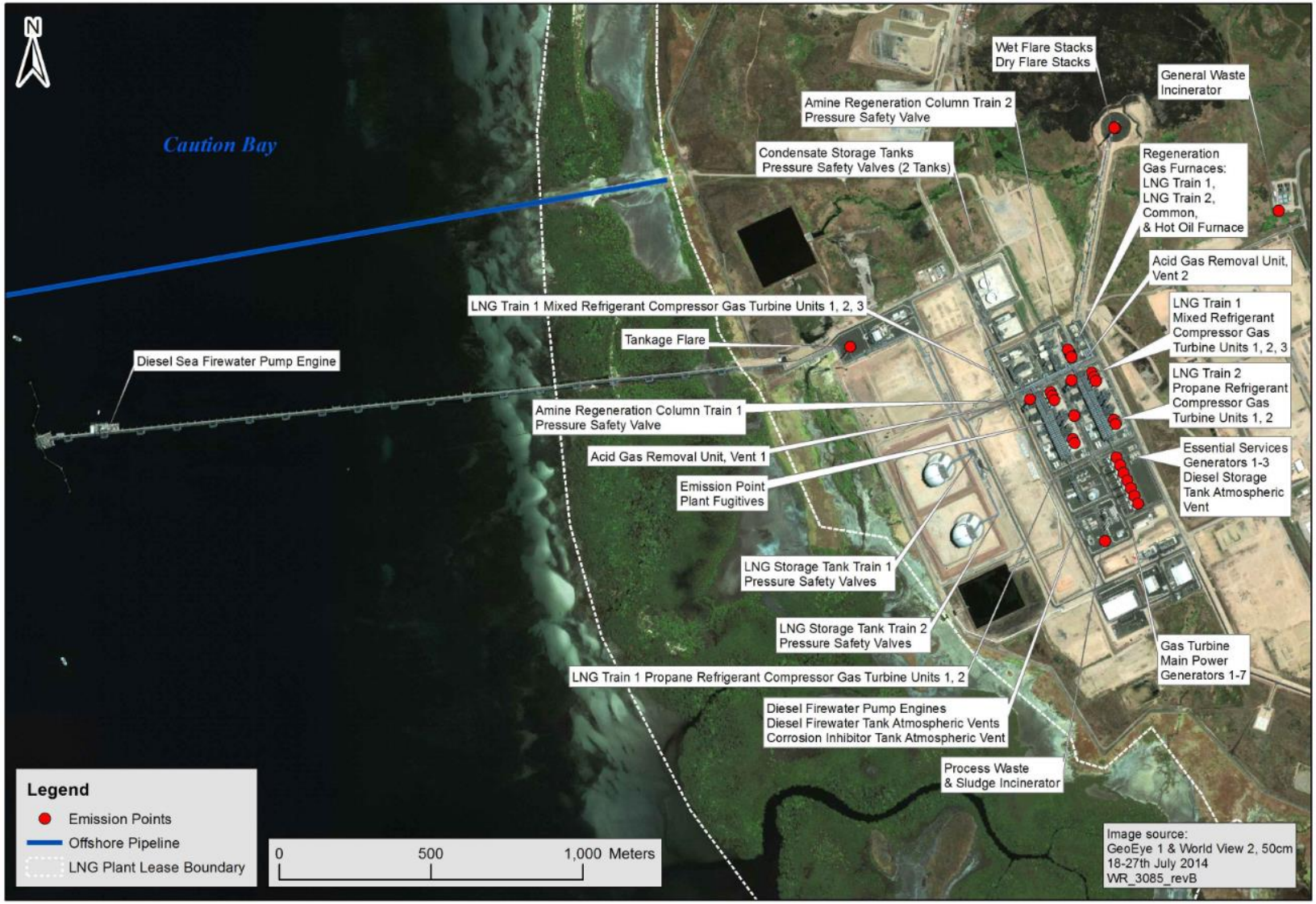

Figure 6-1: LNG Plant emission and discharge sources

6.2.1 Compressor gas turbine exhausts

As part of the refrigeration and liquefaction process, three mixed refrigerant compressor strings operate in two parallel trains (total of six) and two propane refrigerant compressor strings operate in two parallel trains (total of four). All compressors are gas turbine driven and are fitted with dry low emission combustion systems.

Fuel gas is collected from various sources in the process trains and storage facility, including boil-off gases from the LNG storage tanks, and used mainly to fuel the turbines.

Hot exhaust gases from the mixed refrigerant compressor gas turbines are directed to Waste Heat Recovery Units (WHRUs), which provide heating for the LNG Plant hot oil system.

During steady state operations, emissions from the WHRU stacks and propane refrigerant compressor stacks are continuous and the relevant pollutant is oxides of nitrogen.

Table 6-2 shows the design emissions specification for the WHRUs and propane refrigerant compressor gas turbines; and the applicable emission guideline values.

Table 6-2: Compressor gas turbine/Waste Heat Recovery Unit emissions

PARAMETER	DESIGN EMISSION SPECIFICATION	EMISSION GUIDELINE VALUE
Oxides of nitrogen	25 ppm	25 ppm
Source: *Environmental, Health, and Safety General Guidelines (IFC, 2007)*, Table 1.1.2 - Small Combustion Facilities Emissions Guidelines. Emission guideline values stated in parts per million (ppm). Emission guideline values apply at reference conditions of 15 percent oxygen, dry gas. Emission guideline values apply during normal steady state operations, and not to startup, shutdown and abnormal operations.		

The stack height of each WHRU is 44 metres above grade. The stack height of each propane refrigerant compressor is 42 metres above grade. In addition to the low emission combustion system, the stack heights serve to control ground level concentrations of nitrogen dioxide and achieve applicable ambient air quality criteria.

6.2.2 Main power generator exhausts

The main power generators supply electrical power to the LNG Plant through a low and high voltage electrical distribution network. The network consists of seven dry low emission single shaft combustion turbine generators. Six turbine generators operate in parallel, with one spare. Fuel gas is supplied to each turbine from the fuel system (compressed air and high pressure fuel gas). Essential generators, required for a black start/restart of the LNG Plant, are diesel-engine driven.

During steady state operations, emissions from the turbine generators are continuous and the relevant pollutant is oxides of nitrogen.

While operating with diesel as a back-up fuel, emissions of oxides of sulphur from the turbine generators are relevant. *Environmental, Health, and Safety General Guidelines (IFC, 2007)*, Table 1.1.2 - Small Combustion Facilities Emissions Guidelines state that low sulphur fuel (0.5 percent or lower) should be used if commercially available without significant excess fuel cost. Accordingly, low sulphur diesel will be used in the LNGP Diesel System where commercially available and not cost prohibitive.

Table 6-3 shows the design emissions specification for the turbine generators and the applicable emission guideline values.

Table 6-3: Main power generator emissions

PARAMETER	DESIGN EMISSION SPECIFICATION	EMISSION GUIDELINE VALUE
Oxides of nitrogen	25 ppm	42 ppm
Source: *Environmental, Health, and Safety General Guidelines (IFC, 2007),* Table 1.1.2 - Small Combustion Facilities Emissions Guidelines. Emission guideline values for fuel gas at reference conditions of 15 percent oxygen, dry gas. Emission guideline values apply during normal steady state operations, and not to startup, shutdown and abnormal operations.		

The turbine generator stack heights are 44 metres above grade which, in addition to the low emission combustion system, serves to control ground level concentrations of nitrogen dioxide and achieve applicable ambient air quality criteria.

6.2.3 Regeneration gas furnace exhausts

As part of the dehydration and mercury removal process, the molecular sieve beds are dried using regeneration gas. The regeneration gas is heated to approximately 290 degrees Celsius by regeneration gas furnaces, two of which operate continuously in parallel trains with a common spare. Spent regeneration gas downstream of the molecular sieves is cooled through an air cooler and used as a source of fuel gas for the LNG Plant. Combustion efficiency of the regeneration gas furnaces is approximately 80 percent.

6.2.4 Hot oil system furnace exhausts

During startup, when the WRHUs are not available, a hot oil furnace operates to provide heating duty for the LNG Plant hot oil system. The hot oil furnace is also available to supplement the WHRUs when necessary. Emissions from the hot oil furnace are intermittent and *de minimis*[2] and are not considered further in this EMP.

6.2.5 Flare system

The purpose of the flare systems at the LNG Plant is to allow safe disposal of gas and liquid from pressure relief devices and blowdown valves during process upsets, as well as to manage excess fuel gas. Any liquid condensed along the pipeline and relieved from pressure relief devices is collected as part of the flare system. The collected liquid is separated for treatment and the resultant vapour stream is routed to the flare stacks for incineration. The design criteria for the flare systems serves to control ground level concentrations of pollutants in ambient air.

There are three flare systems at the LNG Plant: a wet flare system; a dry flare system; and a tankage gas flare system.

The wet flare system is designed to manage vapour and liquids that are susceptible to freezing during a depressurisation event where sub-zero temperatures can occur. It is sized to handle pressure relief and blow down streams from the inlet area, inlet gas treating systems, fractionation unit, hot oil system and fuel gas systems (including excess fuel gas). Vapours and liquids are collected in the same header and routed to a knock out drum equipped with a built in sparger where defrost gas or boiled off gas is used to vaporise volatile components. Liquids remaining after vaporisation are transferred via a knock out drum pump to the slop oil tank or the neutralisation water tank (for the case where amine relieves from the amine absorber). Vapours are routed to the wet flare for incineration.

The dry flare system is designed to manage vapour and liquid discharges that are not susceptible to freezing at sub-zero temperatures. The system collects moisture-free vapours and liquid hydrocarbons from relief valves, vents, and drains throughout the process areas. The dry flare is sized to handle relief and blow down streams from the liquefaction,

[2] A term used by the United States Environmental Protection Agency to describe emissions levels which are negligible and for which no conformity levels are established.

refrigeration, and fractionation systems. Vapours and liquids are collected and routed to a knock out drum equipped with a built-in sparger where defrost gas or boiled off gas is used to vaporise volatile components. Liquids remaining after vaporisation are transferred to the wet flare knock out drum for disposal as required. Vapours are routed to the dry flare for incineration.

The tankage gas flare system is designed to manage low-pressure relief gases. The tankage flare is sized to handle pressure relief from the LNG storage and loading systems, and from the boil-off gas system. The relief gas is routed directly to the tankage gas flare for incineration. The system is not equipped with a knock out drum as no liquid carry-over is expected from the relief sources.

Continuous pilots are used to ignite all flares and the stacks are continuously purged with nitrogen to prevent ingress of oxygen. Pilot and purge gas emissions consist of nitrogen, oxides of nitrogen, carbon monoxide, and light/volatile hydrocarbons and represent continuous, although *de minimis*, emissions.

Polluting emissions from the flare stacks during design relief cases are oxides of nitrogen, carbon monoxide, light/volatile hydrocarbons and particulates. There are no applicable emission guideline values.

The flares are designed to achieve up to 98 percent thermal destruction efficiency and are designed for smokeless flaring over their operating range. The wet and dry flares use high pressure fuel gas as assist gas for achieving smokeless operation.

The wet flare tip and dry flare tip are located at 93 metres above grade on the same support structure. The tankage flare tip is located at 65 metres above grade.

6.2.6 Process waste incinerator

A diesel fired incinerator with a capacity of more than 300 kilograms per hour has been installed at the LNG Plant to dispose of combustible waste streams. The incinerator is a rotary kiln of dual combustion chamber design that achieves a minimum temperature of 850^{o}C. Combustion temperature in both chambers is maintained via automatic control. A minimum retention time in the secondary combustion chamber of two seconds is achieved via automatic control.

Flue gas from the incinerator is treated through a pollution control system consisting of a wet spray quench and gas cleaning system. The temperature of the flue gases exiting the secondary combustion chamber is quenched by the water spray quench. Drainage from the incinerator area is directed to the effluent treatment system for further collection, treatment and discharge to the permanent retention pond. The cooled flue gas is directed to a gas cleaning system consisting of a baghouse filter for the removal of particulates.

The relevant emission guideline values are shown in Table 6-4.

The height of the stack incinerator is sized which, in addition to the combustion efficiency and pollution control system, serves to control ground level concentrations of residual pollutants in ambient air.

Table 6-4: Process Incinerator emissions

PARAMETER	EMISSION GUIDELINE VALUE
Particulate Matter (PM)	70 mg/m^3
Carbon monoxide	157 ppm
Oxides of nitrogen	388 ppm
Oxides of sulphur	20 ppm

PARAMETER	EMISSION GUIDELINE VALUE
Hydrogen chloride	62 ppm
Cadmium	0.004 mg/m^3
Lead	0.04 mg/m^3
Mercury	0.47 mg/m^3
Dioxin/furan	0.41 ng/m^3
Opacity	10 percent
Source: Based on *Title 40 – Protection of Environment, Part 60 – Standard of Performance for New Stationary Sources [40 CFR 60] (United States Environmental Protection Agency, 2008,)* Subpart CCCC (Standards of Performance for Commercial and Industrial Solid Waste Incineration Units), including threshold for applicability relating to throughput, as referenced in *Environmental, Health and Safety Guidelines for Waste Management Facilities (IFC, 2007)*. Emission guideline values stated in ppm by dry volume, milligrams per standard cubic metre (mg/m^3) and nanograms per standard cubic metre (ng/m^3), as indicated above. Emission guideline values apply during normal steady state operations, and not startup, shutdown and abnormal operations. Emission guideline values for dioxin/furan at toxic equivalency basis. Emission guideline values except opacity are stated at reference conditions of 7 percent oxygen, dry basis at standard conditions.	

6.2.7 General waste incinerator

A diesel fired incinerator with a capacity of more than 150 kilograms per hour operates at the LNG Plant to dispose of general waste streams. The incinerator is a dual combustion chamber design that achieves a minimum temperature of 850^{o}C. Combustion temperature in both chambers is maintained via automatic control. A minimum retention time in the secondary combustion chamber of one second is achieved via automatic control.

Flue gas from the incinerator is treated through a pollution control system consisting of a bank of ceramic filters. The temperature of the flue gases exiting the secondary combustion chamber is reduced via a counter-current flow of ambient air. The cooled flue gas is then dosed with hydrated lime prior to passing through the ceramic filter for the removal of particulates.

The relevant emission guideline values are shown in Table 6-5.

The height of the stack incinerator is sized which, in addition to the combustion efficiency and pollution control system, serves to control ground level concentrations of residual pollutants in ambient air.

Table 6-5: General Waste Incinerator emissions

PARAMETER	EMISSION GUIDELINE VALUE
PM	270 mg/m^3
Carbon monoxide	13 ppm
Oxides of nitrogen	170 ppm
Oxides of sulphur	1.2ppm
Hydrogen chloride	200 ppm
Cadmium	0.67 mg/m^3
Lead	2 mg/m^3
Mercury	0.0035 mg/m^3
Dioxin/furan	31 ng/dscm

Fugitive ash	Visible emissions for no more than 5 percent of the hourly observation period.
Source: Based on Title 40 – Protection of Environment, Part 60 – Standard of Performance for New Stationary Sources [40 CFR 60] (United States Environmental Protection Agency, 2008), Subpart CCCC (Standards of Performance for Commercial and Industrial Solid Waste Incineration Units), Table 8- Emission Limitations for Small, Remote Incinerators That Commenced Construction After June 4, 2010, Or That Commenced Reconstruction or Modification After August 7, 2013 Emission guideline values stated in ppm by dry volume, milligrams per standard cubic metre (mg/m^3) and nanograms per standard cubic metre (ng/m^3), as indicated above. Emission guideline values apply during normal steady state operations, and not start-up, shutdown and abnormal operations. Emission guideline values for dioxin/furan at toxic equivalency basis. Emission guideline values except opacity are stated at reference conditions of 7 percent oxygen, dry basis at standard conditions.	

6.2.8 Pressure control valves and pressure vacuum safety valves

A number of pressure safety valves operate at the LNG Plant to provide pressure relief. Of note, the LNG storage tanks pressure safety valves are sized for extreme high vapour relief conditions (such as a tank fire, rollover of liquid contents or a sudden drop in barometric pressure) and at low pressure it is not practical to vent to the flare. Discharges from the pressure safety valves are directed to the flare systems, resulting in intermittent and *de minimis*[3] and are not considered further in this EMP.

6.2.9 Atmospheric vents

A number of atmospheric vents operate at the LNG Plant. These include, but are not limited to, the diesel storage tank, diesel firewater tank (fuel tank for pumps), and the corrosion inhibitor tank. Carbon dioxide recovered from the feed gas in the acid gas removal unit is vented to atmosphere through a dedicated high point vent at 60 metres above grade. The vent elevation has been selected to ensure that any entrained benzene is adequately dispersed. Emissions that may affect air quality from the atmospheric vents are *de minimis*[i] and are not considered further in this EMP.

6.2.10 Diesel engines

Essential services generators (high-speed diesel) are available for startup, shutdown or when main power generators are unavailable, catering for essential loads at the LNG Plant and Marine Facilities. Diesel engine driven pumps also serve the firewater system. For maintenance purposes, generators and firewater pump engines are regularly serviced and operated for several hours per week.

In the absence of emission guideline values applicable to the operation of the diesel engine generators, preventive maintenance supports operation of the generators in accordance with manufacturer specifications and controls release of pollutants. Low sulphur diesel will be used in the LNG Plant diesel system where commercially available and not cost prohibitive. Emissions from the diesel engines are intermittent and *de minimis* and are not considered further in this EMP.

6.2.11 Landfill emissions

Polluting emissions from landfills include methane and carbon dioxide. A landfill gas collection system that vents to atmosphere will be installed when the landfill cells are capped. Given that the majority of putrescible waste is digested via the wastewater treatment plants or incinerated, and only minimal amount is sent directly to landfill, the venting of landfill gas emissions are considered *de minimis* and are not considered further in this EMP.

[3] A term used by the United States Environmental Protection Agency to describe emissions levels which are negligible and for which no conformity levels are established.

6.3 Fugitive emissions

Fugitive source air emissions refer to emissions that are distributed spatially over a wide area and not confined to a specific discharge point. There are no significant sources of fugitive emissions anticipated at the LNG Plant. Condensate storage tanks use floating roofs with double seals. Valves, pipes and tanks, etc. are regularly inspected and maintained to reduce the potential for fugitive volatile organic compound emissions. Minor fugitive emissions arise from piping and valves, vents, diesel storage tanks, and the laboratory emissions (e.g. fumehoods). Fugitive emissions are *de minimis* and are not considered further in this EMP.

6.4 Greenhouse gas emissions

The primary greenhouse gas emissions associated with the operation of the LNG Plant include:

- combustion of natural gas in the production of LNG including gas used by the site's turbines for power generation, refrigerant compressors, heaters/boilers and the desalination plant
- flaring of natural gas (including pilot flare and assist gas)
- acid gas removal unit vents
- regeneration gas furnace emissions
- combustion of diesel by the site's waste incinerators
- combustion of diesel by vehicles and mobile equipment operated by EMPNG and contractors
- shipping (between pilot station and the LNG facilities) including natural gas, diesel or marine bunkers, heavy fuel oil and marine diesel oil used by ships for transport of the LNG and condensate product
- leaks and accidental releases of gas from gas piping, pipelines or equipment (which only occur under abnormal conditions).

Minimising greenhouse gas emissions was considered during engineering, design and procurement of equipment for the LNG Plant. Aero-derivative turbine technology was selected due to its high fuel efficiency and subsequent lower greenhouse gas emissions, when compared to traditional frame turbine technology. In addition, waste heat recovery units utilise heat from the gas turbine refrigerant compressors' exhausts to provide the main source of heat to the hot oil system.

Greenhouse gas emissions are tracked and reported to internal and external stakeholders as part of EMPNG's environmental performance reporting requirements. Site emission sources are accounted for, including generators, turbine compressors, flares, process vents and mobile sources such as vehicles and tugboats. Direct process fuel usage is used with approved emission factors to calculate the final greenhouse gas emissions. Year-on-year trends are reviewed and any differences noted are used to understand any potential changes in operations.

Greenhouse gas emissions associated with the international shipping of LNG and condensate product from Caution Bay to customers, are tracked.

Greenhouse gas emissions from wastewater treatment and waste disposal are considered to be *de minimis* due to the limited scale and are not considered further in this EMP.

6.5 Dust

Dust may be generated in dry conditions, including around soil and spoil stockpiles. To reduce the occurrence of dust, appropriate vehicle speed limits apply within EMPNG facilities and on public roads. In the event that dust causes a nuisance, appropriate control measures (for example road dampening, covering stockpiles) will be implemented.

6.6 Light

Light has the potential to disturb nocturnal fauna, including turtles on Idihi Island. Potential impacts of perimeter and other lights will be reduced by directing light to where it is required for operations and security, as well as avoiding directing light to the marine environment, where practical.

Where practicable, shielding/treatments for the reduction of light spill into the marine environment will be utilized to reduce visibility of the site from Ihidi Island where turtles may be nesting. Lighting on the jetty has been reduced to the minimum practicable whilst still meeting navigation and security guidelines. Any changes to the jetty or lighting adjacent to Caution Bay will also need to consider this requirement.

7.0 AMBIENT AIR QUALITY

EMPNG's objectives are to avoid significant impacts associated with the release of pollutants to air and meet applicable emissions and air quality criteria.

The ambient air quality guidelines applicable to EMPNG's operations are described in this section. Ambient air quality monitoring is discussed in Section 18.0.

Emissions to atmosphere from the LNG Plant have the potential to result in localised effects on ambient air quality. Applicable ambient air quality guideline values, designed for protection of human health and the environment, are shown in Table 7-1.

Table 7-1: Ambient air quality guidelines

	AVERAGING PERIOD			
	1 HOUR ($\mu G/M^3$)	**24 HOUR ($\mu G/M^3$)**	**ANNUAL ($\mu G/M^3$)**	**OTHER**
Sulphur dioxide	-	20	-	10 minute average: 500
Nitrogen dioxide	200	-	40	-
Carbon monoxide	30,000	-	-	15 minute average: 100,000 30 minute average: 60,000 8 hour average: 10,000
Hydrogen sulphide	-	-	-	No offensive odour at boundary: <5 mg/m^3
PM_{10}	-	150	70	-
$PM_{2.5}$	-	75	35	-
Total suspended particulates	-	150-230	60-90	-
Ozone	-	-	-	8 hours, daily max: 100 (not to be exceeded more than 24 times per year)

Source: Based on *Air Quality Guidelines (World Health Organization, 2006)*, as cited in the *Environmental, Health, and Safety General Guidelines (IFC, 2007)*, Table 1.1.1 - WHO Ambient Air Quality Guidelines.
Ambient air quality values are expressed in micrograms per cubic metre ($\mu g/m^3$) unless otherwise stated.
PM 24-hour value is the 99^{th} percentile.

Several air quality assessments, including the air quality assessments undertaken as part of the PNG LNG EIS and subsequent air quality and dispersion modelling undertaken during detailed design, show that the air quality guideline values shown in Table 7-1 are achievable.

8.0 NOISE

EMPNG's objectives are to avoid significant noise impacts to community and fauna and meet applicable noise criteria.

The noise guidelines applicable to production are described in this section.

Noise from the LNG Plant and Marine Facilities has the potential to cause localised noise impacts to nearby receptors. Noise guidelines applicable to steady state operation of the LNG Plant and Marine Facilities are shown in Table 8-1.

Conditions that are not considered to be part of steady state operations of the LNG Plant and Marine Facilities include plant start-up, plant shutdown, maintenance (planned or unplanned), process upset and any emergency situation.

Table 8-1: Noise guidelines

RECEPTOR	**ONE HOUR EQUIVALENT CONTINUOUS SOUND PRESSURE LEVEL IN A-WEIGHTED DECIBELS (dBA)**	
	DAY	**NIGHT**
Residential, Institutional Educational	55	45
Industrial, Commercial*	70	70
Source: Based on *Environmental, Health, and Safety General Guidelines (IFC, 2007),* Table 1.7.1 Noise Level Guidelines. *Industrial/commercial Guidelines provided as a reference as properties adjacent to the LNG Plant include a mixture of residential, commercial and industrial land uses. IFC noise level guidelines state that noise should not exceed the guideline levels above or result in a maximum increase in background levels of 3dBA at the nearest off-site receptor (i.e. beyond the LNG Plant's lease boundaries), whichever is greater. Day is 07.00-22.00 hours. Night is 22.00-07.00 hours.		

The noise guidelines shown in Table 8-1 are deemed to apply at the nearest receptor outside the LNG Plant's lease boundaries. The layout of noise generating equipment have been designed to achieve these criteria.

The criteria shown in Table 8-1 will be achieved with the exclusion of background noise, more specifically; background noise will be subtracted such that only point source noise from the facility will be accounted for. Conformance will be demonstrated through noise modelling, supplemented by noise monitoring, as discussed further in Section 18.0.

In addition to the above steady state criteria, planned short-term high intensity noise events will be limited and potentially affected communities will be notified in advance of the intended work and its duration wherever possible.

9.0 DISCHARGES TO WATER AND WATER QUALITY

EMPNG's objectives are to avoid significant impacts associated with the release of pollutants to surface water and groundwater and meet applicable discharge criteria.

Information about the discharge of wastewater during production is provided in this section, including a description of the discharges and the applicable discharge criteria/water quality criteria.

Also described below are relevant control measures, including design and operational controls. Monitoring of discharges and water quality is discussed in Section 18.0.

A summary of discharges to water is provided in Appendix 2.

9.1 Discharge locations

Discharges to water at the LNG Plant are listed in Table 9-1. The location of each discharge point is shown in Figure 9-1.

Table 9-1: LNG Plant discharge points

SOURCE	DISCHARGE POINT REFERENCE	TYPE
Stormwater	LNG-S1	Intermittent
Stormwater	LNG-S2	Intermittent
Mixing pit	LNG-S3	Intermittent/continuous
Stormwater	LNG-S4	Intermittent
Retention pond	LNGP-RP1	Continuous
Sanitary WWTP (primary)	LNG-W1	Intermittent
Oily Wastewater Treatment Facility	LNG-W2	Intermittent
Sanitary WWTP (secondary)	LNG-W5	Intermittent
Desalination plant brine discharge	LNGP-RP1 or LNG-S3	Continuous
Landfill leachate	LNG-W1	Intermittent (recovered from landfill and processed by Sanitary WWTP)

Figure 9-1: LNG Plant discharge points

The retention pond is the primary point of receipt for the majority of treated wastewater generated at the LNG Plant. The retention pond is lined with high density polyethylene to prevent release of its contents to the environment. Water from the retention pond is directed to a mixing pit prior to discharging to the Caution Bay receiving environment.

Discharges are managed to avoid significant impacts associated with the release of pollutants to surface water, groundwater, the marine environment, and to meet applicable discharge criteria. Management of each effluent and wastewater source is outlined in the following sections.

9.1.1 Stormwater

A system of open and closed drains is used to separate clean from potentially contaminated surface water.

Stormwater, from uncontaminated areas at the LNG Plant, collects in an open drain system and ultimately discharges to the environment. Stormwater from potentially contaminated areas, including the process area, utility area, effluent treatment system area, power generation area, maintenance area, wet and dry flare drums area, waste storage area and condensate storage area is directed by gravity to sumps or collection pits that provide retention time for initial solids separation and oil water separation. The partially treated water is directed to the oily wastewater treatment facility for further treatment. The treated water is then normally routed to the retention pond before discharging into the environment.

A series of diversion drains, curbing, overflow diversion devices, and grading are used throughout the site to prevent excess clean stormwater runoff from entering potentially contaminated areas.

9.1.2 Oily wastewater treatment system

The oily wastewater treatment system consists of an equalisation tank, a dissolved air flotation unit and sand filters that remove oil and suspends solids in the water. Wastewaters from the following sources are routed to the equalisation tank, which has a baffle and a fixed weir for oil skimming:

- oily water collection pits
- chemical collection pits (non-amine contaminated wastewater)
- chemical wastewater treatment facility.

Skimmed oil from the equalisation tank is collected to an above ground skimmed oil tank and transferred to a slop oil tank. Water from the equalisation tank is fed to a dissolved air flotation unit, which reduces oil content and the treated water is subsequently routed to a sand filter by gravity flow to remove suspended sediment. The treated water is normally discharged to the retention pond before discharging into the environment.

Oily sludge from the dissolved air flotation unit is collected in a sludge tank and incinerated or treated and directly landfilled, dependent upon sludge quality and subject to EMPNG approval.

Grading, sloping and curbs are used to avoid the entrance of other waters, such as clean stormwater, into the oily water drains. Overflow diversion devices are provided upstream of chemical collection pits to divert excess rainwater and firewater to the clean stormwater drainage system.

9.1.3 Waste hot oil

Hot oil from the LNG Plant hot oil system is drained, using nitrogen if necessary, to the hot oil collection drum. The hot oil collection drum is drained by pumping the contents to the slop oil tank and from there to temporary containers. Hot oil that cannot be reused in the system will be incinerated or stored for treatment and reuse by an EMPNG approved third party (see Section 12.0).

9.1.4 Chemical wastewater treatment system

The chemical wastewater treatment facility consists of a neutralization pit with a pH adjustment system. Non-amine contaminated wastewaters collected from the hydrocarbon/water sump pump and reverse osmosis cleaning effluent pit, are routed to the neutralization pit. When pH levels are adjusted, the water is then routed to the equalisation tank of the oily wastewater treatment facility.

9.1.5 Amine-contaminated wastewater

Amine-contaminated wastewater is collected by the amine regenerator reflux pump and wet flare knock out drum pump. These streams are routed to a neutralized water tank and either transferred to the process waste incinerator, or stored for offsite treatment and disposal by an EMPNG approved third party (see Section 12.0).

Where the first flush of water in chemical collection pits is potentially contaminated with amine, the water is routed to the neutralized water tank via a pit pump.

9.1.6 Chemical drainage system (laboratory and chemical storage buildings)

Drains from the laboratory and chemical storage buildings are directed to dedicated sumps. Liquids collected within these sumps are collected by a vacuum truck and depending on their contents either routed to the neutralization pit, neutralised water tank or stored for offsite treatment and disposal.

9.1.7 Sewage

A packaged Wastewater Treatment Plant (WWTP) operates at the LNG Plant to treat sanitary wastewater. The packaged WWTP is operated in accordance with the manufacturer's specifications. Sanitary wastewater is collected and routed to an equalisation tank with a rotating filtering drum. Materials from the rotating drum will normally be incinerated. From the equalisation tank wastewater is directed to a bio-treatment unit. Treated sanitary effluent from the bio-treatment unit is directed to the environment.

Sludge from the bio-treatment unit is incinerated or treated and directly landfilled, dependent upon sludge quality and subject to EMPNG approval.

A second WWTP is also present at the LNG Plant that can also be used to treat sanitary wastewater when the primary WWTP is undergoing maintenance and/or repairs, or camp capacity warrants the operation of both WWTPs. Treated sanitary effluent from the bio-treatment unit is directed to the environment.

9.1.8 Desalination system

Seawater from the seawater intake is transferred to the desalination unit for the production of desalinated water via reverse osmosis. Concentrated brine produced from the desalination unit, along with brine generated in the demineralisation system, is normally mixed with discharges from the retention pond prior to discharge to the environment.

Effluent from the reverse osmosis cleaning process is routed to the neutralization pit of the chemical wastewater treatment facility.

9.1.9 Leachate

Leachate from the LNG Plant landfill will be taken to the WWTP for treatment.

9.1.10 Wash water

The washing of equipment, vehicles or machinery near or within watercourses is prohibited. Washing is only to occur in nominated areas as approved by EMPNG.

Wash-water generated as part of maintaining process equipment is characterised and dependent upon water quality is appropriately treated. For example through the LNGP's

open/closed drain system, or disposed of either to an incinerator or offsite via an approved third party waste provider.

9.2 Water quality and discharge criteria

9.2.1 Receiving water quality criteria

Annex 2 of the Environment Permit sets out applicable water quality criteria, as shown in Table 9-2 and Table 9-3.

Discharges to receiving waters should not cause a lowering of receiving water quality below the criteria shown in Table 9-2. Table 9-3 shows maximum permitted criteria of ammonia-nitrogen for protection of freshwater aquatic life.

Different types of wastewater are discharged from the LNG Plant site. Not all of the water quality criteria prescribed in Annex 2 of the Environment Permit is relevant to each of these discharge types. The criteria relevant to each discharge type are set out in Table 9-6, Table 9-7, Table 9-8, and Table 9-9.

The *Environment (Water Quality Criteria) Regulation 2002* prescribes that a permit that provides for a mixing zone within its terms and conditions shall specify the location and size of the mixing zone and the corresponding water quality criteria that apply at the boundary of the mixing zone. The Environment Permit does not specify a mixing zone.

Table 9-2: Receiving Water quality criteria

PARAMETER	WATER QUALITY CRITERIA (FRESHWATER)	WATER QUALITY CRITERIA (SEAWATER)
pH	6.5 – 9 (pH units)	Within natural pH range
Temperature	No alteration greater than 2 degrees Celsius	No alteration greater than 2 degrees Celsius
Turbidity	No alteration greater than 25 NTU or no change of more than 10 percent above background levels at any particular time (whichever is greater)	No alteration greater than 25 NTU or no change of more than 10 percent above background levels at any particular time (whichever is greater)
Total Suspended Solids	50 mg/L or no change of more than 10 percent above background levels at any particular time (whichever is greater)	50 mg/L or no change of more than 10 percent above background levels at any particular time (whichever is greater)
Dissolved oxygen	Not less than 6 mg/L or no change of more than 10 percent below background levels at any particular time (whichever is smaller)	Not less than 5 mg/l or no change of more than 10 percent below background levels at any particular time (whichever is smaller)
Chemical oxygen demand	125 mg/l	125 mg/l
Biological oxygen demand	25 mg/l	25 mg/l
Sulphate as $SO4^{2-}$	400 mg/l	---
Sulphide as HS-	0.002 mg/l	0.002 mg/l
Ammonia-nitrogen	Dependent on pH and temperature (see Table 9-3)	0.5 mg/l**
Nitrate	45 mg/l	45 mg/l
Potassium	5 mg/l	600 mg/l
Barium	1 mg/l	1 mg/l
Boron	1 mg/l	10 mg/l
Cadmium	0.01 mg/l	0.001 mg/l
Chromium (as hexavalent)	0.05 mg/l	0.01 mg/l

PARAMETER	WATER QUALITY CRITERIA (FRESHWATER)	WATER QUALITY CRITERIA (SEAWATER)
Cobalt	Limit of detection	Limit of detection
Copper	1 mg/l	0.03 mg/l
Iron	1 mg/l	1 mg/l
Lead	0.005 mg/l	0.004 mg/l
Manganese	0.5 mg/l	2 mg/l
Mercury	0.0002 mg/l	0.0002 mg/l
Nickel	1 mg/l	1 mg/l
Selenium	0.01 mg/l	0.01 mg/l
Silver	0.05 mg/l	0.05 mg/l
Tin	0.5 mg/l	0.5 mg/l
Zinc	5 mg/l	5 mg/l
Oil and grease	No visible film (for stormwater runoff and construction discharges) 10 mg/l (for production discharges)	No visible film (for stormwater runoff and construction discharges) 10 mg/l (for production discharges)
Phenol^	0.085 mg/l	0.270 mg/l
2-chlorophenol^	0.340 mg/l	-
4-chlorophenol^	0.160 mg/l	-
2,4-dichlorophenol^	0.120 mg/l	-
2,4,6-trichlorophenol^	0.003 mg/l	-
2,3,4,6-tetrachlorophenol^	0.010 mg/l	-
Pentachlorophenol^	0.0036 mg/l	0.011 mg/l
Methyl diethanolamine (MDEA)**	-	1.50 mg/l
Diethanolamine (DEA)**	-	0.36 mg/l
Ethanolamine (EA)**	-	0.38 mg/l
Piperazine**	-	3.70 mg/l
Faecal contamination risk	Faecal coliform: Not to exceed 200 colonies per 100 ml or no change greater than 10 percent above background levels at any particular time (whichever is greater) **OR** Not to exceed medium faecal contamination risk (refer to Table 9-4 and Table 9-5). **OR** Residual chlorine: as close as possible to 1 mg/l	Faecal coliform: Not to exceed 200 colonies per 100 ml or no change greater than 10 percent above background levels at any particular time (whichever is greater) **OR** Not to exceed medium faecal contamination risk (refer to Table 9-4 and Table 9-5). **OR** Residual chlorine: as close as possible to 1 mg/l

PARAMETER	WATER QUALITY CRITERIA (FRESHWATER)	WATER QUALITY CRITERIA (SEAWATER)
Primary source: Annex 2 of the Environment Permit, based on *Environment (Water Quality Criteria) Regulation 2002*, Water Quality Criteria for Aquatic Life Protection. Metal concentrations are for dissolved substances (passing through a nominal 0.45 µm medium). Cobalt (as 'limit of detectability') uses graphite furnace atomic absorption spectrometry. ^Source: Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, 2000). Trigger values adopted for a slightly to moderately disturbed aquatic ecosystem with a high conservation value (99 percent species level protection). **Site-specific criteria for MDEA, DEA, EA, piperazine and ammonia-nitrogen approved by CEPA in their letter dated 20 April 2017 (reference: 2017_12067.1). Values for boron and potassium agreed with CEPA due to high background levels in Caution Bay.		

Table 9-3: Water quality criteria: ammonia-nitrogen (mg/l)

TEMPERATURE (DEGREES CELSIUS)	pH UNITS		
	7	8	9
5	16.1	1.6	0.2
10	11	1.1	0.1
15	7.5	0.8	0.09
20	5.2	0.5	0.07
25	3.6	0.4	0.06
30	2.6	0.3	0.05
35	1.6	0.2	0.04
Source: Annex 2 of the Environment Permit, based on *Environment (Water Quality Criteria) Regulation 2002*, Water Quality Criteria for Aquatic Life Protection.			

Table 9-4: Faecal contamination risk trigger thresholds

FAECAL CONTAMINATION RISK PARAMETERS	TRIGGER THRESHOLDS	WEIGHTED ASSIGNED VALUES
E.coli	Equivalent to or not to exceed 1000 colonies per 100ml	0.415
Enterococci	Equivalent to or not to exceed 500 colonies per 100 ml	0.289
Ammonia as N	Not to exceed 0.1 mg/l	0.149
Turbidity	Equivalent to or not to exceed 5 NTU	0.25
Total Weighted Risk Value = sum of the weighted assigned values		
Source: Ecowise Environmental 2010, *Smart Water Fund, Characterisation of human health risks derived from stormwater*		

Table 9-5: Faecal contamination risk ranking

TOTAL WEIGHTED RISK VALUE	FAECAL CONTAMINATION RISK	ACTION
<0.25	Low	No further testing
0.25 – 0.8	Medium	Verification testing
>0.8	High	Verification testing
Source: Ecowise Environmental 2010, *Smart Water Fund, Characterisation of human health risks derived from stormwater*		

9.2.2 Discharge criteria: stormwater

Discharges of stormwater from uncontaminated areas of the LNG Plant will, at the point of discharge to surface waters, meet the criteria set out in Table 9-6.

Table 9-6: Discharge criteria: stormwater

PARAMETER	DISCHARGE CRITERIA
pH	6.5 – 9 (pH units)
Turbidity	No alteration greater than 25 NTU or no change of more than 10 percent above background levels at any particular time (whichever is greater)
Dissolved oxygen	Not less than 5 mg/l or no change of more than 10 percent below background levels at any particular time (whichever is smaller)
Total Suspended Solids	50 mg/l or no change of more than 10 percent above background levels at any particular time (whichever is greater)
Oil and grease	No visible film
Source: Annex 2 of the Environment Permit, based on *Environment (Water Quality Criteria) Regulation 2002*, Water Quality Criteria for Aquatic Life Protection, as deemed relevant to the discharge of stormwater from uncontaminated areas.	

9.2.3 Discharge criteria: LNG Plant retention pond

Discharges from the LNG Plant retention pond will, at the point of discharge to surface waters, meet the criteria set out in **Table 9-7**.

Concentrated brine from the desalination and demineralization units are normally mixed with discharges from the LNG Plant retention pond prior to discharge to the environment. Mixed discharges will, at the point of discharge to the surface water, also meet the criteria set out in Table 9-7.

Table 9-7: Discharge criteria: LNG Plant retention pond

PARAMETER	WATER QUALITY CRITERIA
pH	6.5 – 9 (pH units)
Temperature	No alteration greater than 2 degrees Celsius
Dissolved oxygen	Not less than 5 mg/l or no change of more than 10 percent below background levels at receiving environment (whichever is smaller)
Total Suspended Solids	50 mg/l
Chemical oxygen demand	125 mg/l
Biological oxygen demand	25 mg/l
Sulphate as $SO4^{2-}$	---
Sulphide as HS-	0.002 mg/l
Ammonia-nitrogen	0.5 mg/l**
Nitrate	45 mg/l
Potassium	600 mg/l
Barium	1 mg/l
Boron	10 mg/l
Cadmium	0.001 mg/l
Chromium (as hexavalent)	0.01 mg/l
Cobalt	Limit of detection

PARAMETER	WATER QUALITY CRITERIA
Copper	0.03 mg/l
Iron	1 mg/l
Lead	0.004 mg/l
Manganese	2 mg/l
Mercury	0.0002 mg/l
Nickel	1 mg/l
Selenium	0.01 mg/l
Silver	0.05 mg/l
Tin	0.5 mg/l
Zinc	5 mg/l
Oil and grease	10 mg/l
Phenol^	0.270 mg/l
2-chlorophenol^	-
4-chlorophenol^	-
2,4-dichlorophenol^	-
2,4,6-trichlorophenol^	-
2,3,4,6-tetrachlorophenol^	-
Pentachlorophenol^	0.011 mg/l
Methyl diethanolamine (MDEA)**	1.50 mg/l
Diethanolamine (DEA)**	0.36 mg/l
Ethanolamine (EA)**	0.38 mg/l
Piperazine**	3.70 mg/l
Faecal contamination risk€	Faecal coliform: Not to exceed 200 colonies per 100 ml **OR** Not to exceed medium faecal contamination risk (refer to Table 9-4 and Table 9-5). **OR** Residual chlorine: as close as possible to 1 mg/l

Primary source: Annex 2 of the Environment Permit, based on *Environment (Water Quality Criteria) Regulation 2002*, Water Quality Criteria for Aquatic Life Protection, as deemed relevant to the discharge of process wastewater.

Metal concentrations are for dissolved substances (passing through a nominal 0.45 µm medium).

Cobalt (as 'limit of detectability') uses graphite furnace atomic absorption spectrometry.

^Source: Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, 2000). Trigger values adopted for a slightly to moderately disturbed aquatic ecosystem with a high conservation value (99 percent species level protection).

**Site-specific criteria for MDEA, DEA, EA, piperazine and ammonia-nitrogen approved by CEPA in their letter dated 20 April 2017 (reference: 2017_12067.1).

Values for boron and potassium agreed with CEPA due to high background levels in Caution Bay.

€Criteria for faecal contamination risk only applies when effluent from the sanitary wastewater treatment plant(s) are discharged into the LNG Plant retention pond

9.2.4 Discharge criteria: oily wastewater treatment system

Discharges from the oily wastewater treatment system will, at the point of discharge to surface waters, meet the criteria set out in Table 9-8.

Table 9-8: Discharge criteria: oily wastewater treatment system

PARAMETER	DISCHARGE CRITERIA
pH	6.5 – 9 (pH units)
Ammonia nitrogen**	0.5 mg/l
Total Suspended Solids	50 mg/l
Oil and grease	10 mg/l
Methyl diethanolamine (MDEA)**	1.50 mg/l
Diethanolamine (DEA)**	0.36 mg/l
Ethanolamine (EA)**	0.38 mg/l
Piperazine**	3.70 mg/l
Primary source: Based on Annex 2 of the Environment Permit as deemed relevant to the discharge from the oily wastewater treatment system ** Site-specific criteria for MDEA, DEA, EA, piperazine and ammonia-nitrogen approved by CEPA in their letter dated 20 April 2017 (reference: 2017_12067.1).	

9.2.5 Discharge criteria: sanitary wastewater treatment plant

Discharges from the WWTP treating sewage at the LNG Plant will, at the point of discharge to surface waters, meet the criteria set out in Table 9-9.

WWTPs using biological digestion technology require a period of stabilisation in order to achieve steady operations. In the event WWTPs treating sewage are replaced or repaired, then the discharge criteria set out in Table 9-9 does not apply at the end of pipe (at the discharge location), during the 90-day commissioning period. However, the quality of the receiving water body must meet the criteria below.

Table 9-9: Discharge criteria: sanitary wastewater treatment plants

PARAMETER	DISCHARGE CRITERIA
pH	6.5 – 9 (pH units)
Biological oxygen demand	25 mg/l
Chemical oxygen demand	125 mg/l
Ammonia nitrogen**	0.5 mg/l
Total Suspended Solids	50 mg/l
Oil and grease	10 mg/l
Faecal contamination risk	Faecal coliform: Not to exceed 200 colonies per 100 ml **OR** Not to exceed medium faecal contamination risk (refer to Table 9-4 and Table 9-5). **OR** Residual chlorine: as close as possible to 1 mg/l
Primary source: Based on Annex 2 of the Environment Permit as deemed relevant to the discharge of WWTPs. ** Site-specific criteria for MDEA, DEA, EA, piperazine and ammonia-nitrogen approved by CEPA in their letter dated 20 April 2017 (reference: 2017_12067.1).	

10.0 SPILL PREVENTION AND RESPONSE

EMPNG's objectives are to prevent spills of hydrocarbons and chemicals and to respond effectively to spills should they occur.

Management measures to prevent the spillage or release of fuels and chemicals, including hazardous chemicals, to the environment, and the actions to be taken in the event of a spill or release, are described in this section.

Control measures including design and operational controls, have been developed in accordance with requirements and through the methods prescribed under OIMS. Relevant OIMS processes include OIMS System 2-1 Risk Assessment and Management, OIMS System 6-5 Environmental Management, OIMS System 9-1 Incident Management and OIMS System 10-2 Emergency Preparedness and Response.

10.1 Transport of fuel and chemicals

Fuel and chemicals will generally be delivered to the LNG Plant and Marine Facilities by third party suppliers, primarily from Port Moresby. EMPNG will take responsibility for purchased fuel and chemicals upon receipt.

As part of the procurement process, the agreements in place between EMPNG and third party suppliers will include minimum requirements relating to spill prevention, preparedness and response. Third party suppliers of fuel and chemicals are subject to prior assessment and approval. Follow-up assessments of third parties will be undertaken periodically.

In the case of transfer by road by EMPNG directly or its contractors, fuel will be transported in purpose-built tankers and chemicals will be transported in fit-for-purpose vehicles and containers. Vehicles used for the transport of fuel and chemicals will carry spill kits appropriate for the type of cargo. Vehicles, and containers will be regularly inspected and maintained as part of preventive maintenance. Drivers responsible for the transport of fuel and chemicals will receive appropriate training, including spill response and leak prevention; and drivers will have the required driving licence.

10.2 Fuel storage and transfer

Diesel fuel is stored at the LNG Plant diesel system in a 100 cubic metre tank. The tank is purpose-built above ground and includes secondary containment sufficient to enable containment of 110 percent of the storage capacity of the largest vessel present.

Integrity of diesel transfer facilities, including transfer lines, vehicles and associated pumps and couplings, will be routinely inspected as part of preventive maintenance and appropriate procedures are in place for their use. Spill kits are regularly inspected, replenished and readily available for all fuel storage and transfer areas. Nominated personnel will receive appropriate training, including spill response and leak prevention.

Diesel is not required for the main process during normal operations but is provided for the essential services generators and the diesel firewater and sea firewater pumps. Diesel is also used to fuel mobile operations equipment at the LNG Plant and Marine Facilities. Purpose-built fuel bowsers provide for refuelling mobile equipment.

Any additional fuel storage that may be required at the LNG Plant will ensure that the vessels are at a minimum above ground, purpose-built and have sufficient secondary containment (minimum of 110 percent of the largest vessel). In addition, temporary fuel storage that may be required at remote locations will not be located less than 30 m from any surface waters unless approved by EMPNG on a case by case basis. Refuelling will be undertaken by appropriately trained personnel with a minimum of two persons present. Drip trays will be used where appropriate during refuelling and a spill kit will be available.

10.3 Chemical storage and transfer

Chemicals are stored at various locations at the LNG Plant. Chemical storage facilities are purpose-built and include secondary containment sufficient to enable containment of 110 percent of the storage capacity of the largest vessel present, and spill response measures appropriate for the size and type of chemical being stored. Integrity of chemical transfer facilities including transfer lines, vehicles and associated pumps and couplings, will be routinely inspected as part of preventive maintenance and appropriate procedures are in place for their use. Spill response kits are regularly inspected and replenished as required. Any future chemical storage installations will ensure that same measures are implemented.

10.4 Condensate storage and transfer

Condensate product from the fractionation system is transferred to the condensate storage tanks. There are two condensate storage tanks of 11,600 cubic metres. The tanks have bunding providing 110 percent of the largest tank capacity.

Condensate is loaded from the combined LNG/condensate loading berth to condensate vessels and appropriate procedures are in place for the transfer. An emergency shutdown system is installed to reduce the risk of spills. Condensate spill containment is provided for the jetty and a spill basin is provided to prevent release of condensate to sea.

The marine terminal also contains spill response measures appropriate for the size and type of spills that could occur during condensate transfer to vessels or spills from vessels themselves. Oil spill response equipment, including dispersants, is also stored on support vessels (example tugboats) used to guide condensate vessels within the Caution Bay shipping channel.

10.5 LNG storage and transfer

LNG produced in the liquefaction section of the process area is directly rundown to the LNG storage tanks via a common rundown header. Back-pressure control valves are provided on top of each tank to ensure the rundown system remains liquid-full. There are two LNG storage tanks of 160,000 cubic metres. The tanks are of single containment design with bunds providing 110 percent of the largest tank capacity.

Loading pumps are installed in each LNG storage tank for transfer of LNG to vessel via a common loading line and appropriate procedures are in place for the transfer. During holding mode, the loading line is maintained cold by circulating LNG. At the loading berth, loading arms and a vapour return arm are provided for loading.

An emergency shutdown system is installed to reduce the risk of product spills and mechanical damage to the loading arms. The first stage is shutdown of cargo transfer and the second stage is release of loading arms.

The grade of the LNG Plant process area is sloped to an insulated concrete trench running parallel to the process area to collect potential LNG spills and then routed away from sources of ignition and collected in a sump. Potential cryogenic spill exposed areas have been identified and structural support elements located within these areas are provided with adequate protection such as concrete coating and insulation. Fixed high-expansion foam systems are provided for cryogenic spill vaporisation reduction at relevant locations.

The jetty loading platform is designed to route LNG spills to sea via a dedicated spill collection system consisting of a cold-spill resistant drip pan and downcomers located under equipment where leaks of LNG could occur. Cryogenic spill protection is installed for the loading platform area and supporting piles.

The marine terminal also contains spill response measures appropriate for the size and type of spills that could occur during LNG transfer to vessels or spills from vessels themselves. Oil spill response equipment, including dispersants, is also stored on service vessels (example tugboats) used to guide LNG vessels within the Caution Bay shipping channel.

10.6 Spill response

Third party suppliers of fuels and chemicals are responsible for responding to a spill or release at their own facilities or while in transit. EMPNG will assess third party suppliers prior to approval and will review spill response arrangements. The agreements in place between EMPNG and third party suppliers will include minimum requirements relating to spill preparedness and response. Follow-up assessments of third parties will be undertaken periodically.

EMPNG will respond to a spill or release of fuel or chemical at EMPNG facilities, or while in transit by EMPNG or its contractors between EMPNG facilities, or when agreed to in writing with a third party. The level of spill response is dependent upon the potential impact of the spill. In general, spills are categorised as Tier 1 (within the capability of EMPNG to respond on-site), Tier 2 (exceeds the capability of EMPNG's on-site resources) and Tier 3 (exceeds available resources in Papua New Guinea and requires resources to be mobilised internationally). EMPNG will respond to Tier 1 spills directly using on-site resources. In the case of a Tier 2 spill, EMPNG will respond using on-site resources and resources mobilised from other EMPNG facilities. An appropriate number of staff will be trained in the handling of emergency response and spill scenarios.

Further details about EMPNG's prevention and response to spills of hydrocarbons are provided in EMPNG's Oil Spill Contingency Plan.

Subsequent to a spill where significant site contamination has occurred, action will be taken to remediate the site and prevent any further impacts to the environment, or human health risks. A site-specific risk assessment will be undertaken to identify human health and environmental risks associated with the contaminated site. Corrective actions and monitoring needs will be evaluated as part of the assessment. Appropriate management and monitoring plans will be developed using information gathered during the inspection.

11.0 MATERIALS MANAGEMENT

EMPNG's objectives are to avoid significant impacts associated with the procurement and use of raw materials and to use materials that are less hazardous or otherwise preferable from an environmental perspective, where practical.

Controls necessary to achieve the above objectives relating to the use and management of materials, including prohibited substances, hazardous materials, water, aggregate and quarry materials and timber, are described in this section.

11.1 Materials review

Materials used during production will be reviewed periodically to determine whether alternative materials are available which are less hazardous or otherwise preferable from an environmental perspective, and to evaluate opportunities for waste reduction.

11.2 Prohibited substances

EMPNG will avoid the use of chemicals and hazardous materials subject to international bans or phase-outs due to their high toxicity to living organisms, environmental persistence, potential for bio-accumulation, or potential for depletion of the ozone layer, consistent with the objectives of the *Stockholm Convention on Persistent Organic Pollutants*, *Montreal Protocol on Substances that Deplete the Ozone Layer* and *Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade*.

EMPNG will also avoid the use of lead-based coatings, primers, paints and lubricants; leaded thread compounds; fluorescent lights containing high levels of mercury; asbestos; chlorinated solvents (e.g. carbon tetrachloride); chromate corrosion inhibitors and heavy metals (such as in reverse emulsion breakers and grit blast).

11.3 Hazardous materials

EMPNG will seek to reduce the use of hazardous materials by evaluating opportunities to use alternative materials that are less hazardous or otherwise preferable from an environmental perspective.

Where the use of a hazardous material (including radioactive material, spontaneously combustible materials) is unavoidable, product-specific controls will be implemented. Controls may include engineering (e.g. alarms, shut-off systems) or operational controls commensurate with the nature of the hazard.

In general, hazardous materials will be stored separately pursuant to compatibility requirements, within a covered area. Hazardous materials containers and vessels will be clearly labelled with the name and description of the hazardous material. Material Safety Data Sheets will be readily available and prominently displayed in relevant storage areas. Personnel will be trained in the handling of hazardous materials in accordance with specific job responsibilities.

11.4 Surface water and groundwater abstraction

Seawater is used for the desalination system and there is no planned abstraction of other surface or groundwater during normal operation of the LNG Plant and Marine Facilities.

Should surface water abstraction be required, and where there is potential for the abstraction to have adverse effects on downstream users and/or environmental flows, generally when the proposed abstraction is in excess of 10 percent of indicative stream flow, EMPNG will conduct an environmental assessment, and the abstraction will be managed so as to mitigate identified impacts.

Water abstraction permits will be obtained where necessary and conditions adhered to, pursuant to the Environment Permit.

In case of demonstrable disruption to community water supply as a result of water abstraction or other activity, EMPNG will provide an alternate water supply, pursuant to the Environment Permit.

11.5 Aggregate and quarry material

New quarries developed by EMPNG or directly on behalf of EMPNG are permitted under the Environment Permit and additional permits are not necessary. Where practicable, EMPNG will reduce the number of quarries developed by using previously worked (old) quarries, and use limestone generated by construction activities.

Prior to the development of new quarries a pre-disturbance survey will be undertaken of the area to be affected and environmental and social sensitivities will be identified. Pre-disturbance surveys will be undertaken by competent professionals.

On the basis of the pre-disturbance survey results, site-specific mitigation and management measures will be adopted to avoid and/or otherwise mitigate identified sensitivities prior to and/or during exploitation of the quarry and render the quarry area safe upon abandonment.

Aggregate and quarry material (including concrete) purchased from third party suppliers will be sourced from legal quarries/borrow pits that are in possession of permits where necessary. To ensure that the facilities and operations of third party suppliers of aggregate and quarry material are fit-for-purpose, they are subject to prior assessment and approval.

Additional approvals will be sought in the event aggregate needs to be sourced from a water body, including ephemeral streams and flood plains (including aggregate purchased from third parties).

11.6 Timber

Timber and wood products purchased from third party suppliers will be sourced from EMPNG-approved, legal operations that are in possession of permits where necessary and operate in an environmentally acceptable manner.

To ensure that the operations of third party suppliers are fit-for-purpose, they are subject to prior assessment and approval.

EMPNG promotes to the extent practical the reuse of timber felled during any site clearing that may occur for construction type activities undertaken by or on behalf of EMPNG.

12.0 WASTE

EMPNG's objectives are to apply the waste management hierarchy and to manage and dispose of waste at EMPNG facilities and approved third party facilities only.

Measures to prevent, mitigate and otherwise control potential significant environmental impacts associated with waste are described below. Information about waste to be generated during production and a description of how waste will be managed, including design and operational controls, is also provided.

The control measures set out in this section, including design and operational controls, and waste management procedures, that have been developed in accordance with the waste management requirements prescribed in OIMS System 6-5 Environmental Management.

12.1 General provisions

EMPNG will apply the waste minimisation and management hierarchy where practical, by prioritising the avoidance and reduction of waste in the first instance, followed by reuse, recycling and recovery, with treatment and disposal being the least preferable options.

All third parties and third party facilities receiving EMPNG waste for purposes of reuse, recycling and recovery are subject to prior assessment and approval by EMPNG. EMPNG's assessment process documents whether potential third parties have in place the required regulatory, environmental, social and safety measures appropriate for the type of waste being processed.

EMPNG waste facilities or EMPNG approved third party facilities will be used for the treatment and disposal of wastes. Where wastes are transferred to a third party, duty of care applies and the transfer of wastes is subject to formal audit and approval by EMPNG.

Wastes are categorised as either non-restricted or restricted depending on their toxicity and treated accordingly at EMPNG or EMPNG-approved third party facilities.

Non-restricted wastes are those that do not pose an immediate threat to health, safety and/or the environment (examples are, but not limited to, canteen waste, paper, cardboard, packing materials, scrap metal, rubble, timber and plastic).

Restricted wastes are those that are easily ignited, corrosive or reactive, toxic, pathogenic or otherwise hazardous (examples are, but not limited to, oils and greases, oil-contaminated rags, containers, filters, degreasing agents, fluorescent tubes, batteries, and health care or biohazard waste).

Appropriate technologies, including use of special containers, segregation and handling procedures apply to the treatment and disposal of biological, pharmaceutical and medical wastes.

An indicative inventory of wastes is shown in Table 12-1. An inventory of wastes will be maintained in a register. The register describes and categorises each type of waste and sets out provisions for its management. It also includes a waste record section that describes the quantities and ultimate fate of each waste generated.

Table 12-1: Typical waste types, treatment and disposal methods

CLASSIFICATION	WASTE DESCRIPTION	TREATMENT	DISPOSAL
Restricted	Incinerator ash	Stabilise	Landfill
	Chemicals, including amine wastewater	Recycle, stabilise and/or incinerate	Landfill (where proven to be stabilised) Incinerator ash to landfill
		Contain	Third party
	Batteries	Recycle or stabilise	Landfill (where proven to be stabilised)
	Activated carbon (spent) – acid gas removal unit	Contain	Third party
	Medical waste	Incinerate	Incinerator ash to landfill
	Sanitary sludge	Dewater/conditioned, and either incinerate or directly landfill (i.e. no further treatment required)	Incinerator ash to landfill or direct landfill
	Contaminated soil and absorbent	Incinerate	Incinerator ash to landfill
	Aerosol canisters	Crush	Landfill
		Contain	Third party recycle
	Oils and greases	Incinerate	Incinerator ash to landfill
		Stabilize (e.g. polymerization of grease trap waste)	Landfill
		Contain	Third party recycle
	Process sludges	Incinerate	Incinerator ash to landfill
	Oily debris and oil filters	Incinerate	Incinerator ash to landfill
	Other filters	Incinerate	Incinerator ash to landfill
	Paint (oil-based)	Stabilise and/or incinerate	Landfill (where proven to be stabilised) Incinerator ash to landfill
	Paint (water-based)	Dewater, stabilise and/or incinerate	Landfill (where proven to be stabilised) Incinerator ash to landfill
	Fluorescent tubes/light bulbs	Contain	Third party

CLASSIFICATION	WASTE DESCRIPTION	TREATMENT	DISPOSAL
	Sewage	Wastewater treatment plant	Treated water discharges to environment
	Landfill leachate	Natural evaporation / recirculation through landfill	Landfill-
		Wastewater treatment plant	Treated water discharges to environment
Non-restricted	Incinerator ash	No onsite treatment required where non-restricted	Landfill
	Barrels/containers, including plastic and metal drums	Clean, contain	Reuse on site
		Clean, crush and/or shred	Landfill
	Tyres	De-bead	Reuse on site
		De-bead, shred, incinerate	Incinerator ash to landfill
	Rubber	Shred, incinerate	Landfill
	Timber	Contain	Reuse on site
		Shred, incinerate	Incinerator ash to landfill
	Putrescible	Liquid food composter	Water treatment plant
		Incinerate	Incinerator ash to landfill
	Green waste	Compost	Reuse on site
		Incinerate	Incinerator ash to landfill
	Construction and demolition debris	Segregate, contain	Reuse on site or third party recycle
		No onsite treatment required	Landfill
	Electrical goods	Contain	Third party recycle
		Shred	Landfill
	Metals (equipment/parts/offcuts)	Contain	Third party recycle
		Shred	Landfill
	Molecular sieve (spent) – dehydration unit	Contain	Third party
	General refuse	Incinerate	Incinerator ash to landfill
		Contain	Third party recycle

CLASSIFICATION	WASTE DESCRIPTION	TREATMENT	DISPOSAL
	Brine concentrate from desalination and demineralization units	Mix with LNG Plant retention pond discharge	Treated water discharges to environment
	Concrete washings	pH adjusted, sediments removed	Treated water discharges to ground
Note: Actual waste types and treatment/disposal methods may vary. An inventory of actual wastes and treatment/disposal methods is maintained in the register of wastes.			

12.2 Waste avoidance and minimisation

The potential for waste generation is considered at the early stage of materials selection. As discussed in Section 11.0 materials used during production will be reviewed periodically to evaluate opportunities for waste reduction.

12.3 Waste from third parties

EMPNG may accept waste (restricted and unrestricted) from third party sources. Prior to accepting waste from third parties, EMPNG will assess the type, volume, ability to store and process the waste, any potential impact to EMPNG's ability to manage its own waste (current and future needs), and whether a net overall benefit exists to the community and environment by accepting such waste.

Third party waste accepted by EMPNG will undergo the same level of management and controls that are applied to EMPNG's own waste.

12.4 Waste collection

Non-restricted wastes will be separated at source into labelled receptacles. The contents of the receptacles will be collected periodically and transferred to the LNG Plant Waste Management Area (LNGP WMA) for further sorting as necessary or EMPNG approved third party facilities.

Restricted wastes will be separated at source at designated collection points that enable appropriate segregation and storage of waste pursuant to compatibility requirements. The restricted waste collection points are secure and covered with appropriate containment to prevent release to the environment. The contents of the restricted waste collection points will be transferred periodically to the LNGP WMA or EMPNG approved third party facilities.

Non-routine wastes will be categorised as part of the register of wastes and provisions for their management will be determined prior to transfer to the LNGP WMA or EMPNG approved third party facilities.

12.5 Waste storage

The LNGP WMA provides for the separate storage of non-restricted and restricted wastes in a manner which facilitates subsequent management (reuse, recycling, recovery, treatment and disposal). Wastes transferred to the LNGP WMA will be verified and documented upon receipt. Wastes will be screened to ensure only acceptable waste types are received and the weight and/or volume of wastes will be recorded.

Restricted wastes will be stored, separately pursuant to waste compatibility requirements, within a covered area with appropriate containment to prevent release to the environment.

12.6 Waste reuse, recycling and recovery

In accordance with the waste minimisation and management hierarchy, wastes will be preferentially reused, recycled or recovered.

Third parties and third party facilities receiving EMPNG waste for purposes of reuse, recycling and recovery are subject to prior assessment and approval by EMPNG.

12.7 Waste treatment and disposal

Wastes that cannot be reused, recycled and/or recovered will be treated and disposed of at the LNGP WMA or EMPNG approved third party facilities. At the LNG Plant, treatment and disposal generally consists of the following key activities:

- treatment (pre-treatment as necessary in preparation for incineration/disposal)
- incineration (of combustible wastes)
- ash stabilisation (handling and stabilisation of bottom and fly ash from incineration)

- landfill (disposal of non-restricted waste that is not suitable for incineration and ash residues from the incineration process)
- sanitary sludge drying bed (sanitary WWTP biosolids)
- landfarming (large volumes of hydrocarbon-impacted soil, sediment will be bioremediated)
- leachate treatment (treatment of landfill leachate).

Each process is outlined below.

12.7.1 Treatment

Treatment of solid wastes in preparation for incineration or disposal to landfill may include, as appropriate, dewatering or crushing of metal and plastic drums.

12.7.2 Incineration

Combustible wastes (material that will burn effectively such as organics, paper/cardboard and plastics) will be incinerated.

12.7.3 Ash stabilisation

Bottom and fly ash from the incineration process is subject to the toxicity characteristic leaching procedure to determine its hazard category. Ash categorised as non-restricted will be directed to landfill without further treatment. Ash categorised as restricted will be stabilised in cement, tested, and then directed to an EMPNG or EMPNG-approved landfill.

12.7.4 Land-farming

Large volumes of hydrocarbon impacted soil, sediment or sludge shall be bioremediated on site through land-farming and/or other bio-piling techniques. Bioremediated material will be sampled and categorised depending on analytical results obtained. Depending on categorisation, bioremediated material will be reused on-site or landfilled.

12.7.5 Landfill

The LNG Plant has an on-site engineered solid waste landfill within the property limits for the disposal of non-combustible non-restricted solid waste including the incinerator residue ash.

The landfill is intended to receive non-restricted wastes. It is constructed with a barrier liner of high-density polyethylene geo-membrane liner and geo-synthetic clay layers.

The design of the landfill provides for up to two separate cells, which will be developed sequentially over time as required, with each cell being filled and covered prior to the next cell being commissioned. The cells are to be separated by internal bunds, which will provide for stormwater and leachate management and each will be provided with a leachate sump.

In order to avoid damage to the geo-membrane liner, waste will be placed with care (for example, avoidance of rigid wastes) over the entire base of the cell until a sufficiently compacted base has been established. Waste will then be added to the active face and compacted from the base up in layers. A cover of earthen material (with low clay and organic content) will be placed periodically over the waste that has been added in order to prevent wind-blown litter and suppress odour. When a cell reaches capacity, an interim cover of earthen material will be put in place to secure the surface.

Final covering of landfill cells will be undertaken in stages, but in general will occur as soon as practicable in order to reduce ingress of rain and hence generation of leachate and to collect and vent landfill gases. The final cover will consist of landfill gas distribution, venting and appropriate cover. A diagram of the LNG Plant landfill is shown in Figure 12-1.

12.7.6 Sanitary sludge drying bed

The sanitary sludge drying bed allows biosolids from the sanitary waste water treatment plant to dewater and undergo basic microbial deactivation prior to landfilling. Treatment of sanitary

sludge includes dewatering via geotubes, sludge holding and in some cases, liming. Effluent from the sanitary sludge drying bed is transported to the sanitary waste water treatment plant for processing.

12.7.7 Leachate treatment

Leachate from the landfill will be directed to the WWTP for treatment.

12.8 Waste tracking and documentation

Wastes will be tracked and documented through all stages of the management process, from the point of generation and collection, through to storage, treatment and final disposal at the LNG Plant or transferred to EMPNG approved third party facilities for reuse, recycling, recovery and/or final disposal.

A waste manifest will be completed upon collection of wastes. The manifest identifies the point of generation and the type, volume/quantity and categorisation of the waste.

Waste received at the landfill will be inspected and the waste manifest will be verified as part of the waste acceptance process. Similarly, waste received at the incinerators will be inspected and the waste manifest verified as part of the waste acceptance process. The waste manifest will be updated with details of the fate of the wastes.

Waste incineration records will be maintained for all burn cycles of the incinerators to track the type and quantity of incinerated wastes. A landfill acceptance record will be maintained to track the type and quantity of all wastes disposed of to landfill.

Wastes transferred from the LNG Plant to third party facilities for reuse, recycling, recovery and/or disposal will be accompanied by a waste transfer record identifying the type and quantity of wastes being transferred including details and signatures of the shipper and receiver.

Information from the waste manifest, waste incineration record, landfill acceptance record and waste transfer record documents will be compiled in the register of wastes.

For hazardous chemicals, materials and wastes from project shipping vessels, their storage, use and handling must be in accordance with IMO MARPOL (1973/1978) requirements and applicable international port policies and procedures.

12.9 Waste monitoring

EMPNG will undertake periodic inspections of the waste management process from the point of generation and collection, through to storage, treatment and final disposal. Inspections are discussed further in Section 19.0.

12.10 Export of restricted waste

EMPNG may at its discretion export certain restricted wastes for treatment and disposal. In such cases, applicable provisions of the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal* and the *Waigani Convention: Convention to Ban the Importation of Hazardous and Radioactive Wastes into Forum Island Countries and to Control the Transboundary Movement and Management of Hazardous Waste within the South Pacific Region* will be applied.

Third parties and third party facilities receiving exported restricted waste are subject to prior assessment and approval by EMPNG.

Figure 12-1: LNG Plant landfill layout

13.0 EROSION AND SEDIMENT CONTROL

EMPNG's objectives are to control significant erosion and prevent sedimentation of surface waters.

Land disturbed for temporary facilities and infrastructure, along with land in the immediate vicinity of permanent facilities and infrastructure, were reinstated following construction. Reinstatement works included temporary and permanent measures to control erosion.

Provisions for ongoing monitoring and maintenance of permanent erosion control works and measures to control potential environmental impacts associated with erosion and sedimentation, are described in the following sections.

13.1 Inspection

EMPNG will conduct inspections within and in the immediate vicinity of the LNG Plant and Marine Facilities. The integrity of permanent erosion control structures and other measures in place to control erosion will be checked as part of the inspections. Particular attention will be paid to areas in the vicinity of surface waters, where sedimentation could occur.

13.2 Maintenance and remedial action

Where deemed necessary, for example to protect asset integrity and/or prevent sedimentation of surface waters, EMPNG will respond to erosion, slope stability and/or sedimentation issues. In particular, existing alongshore sediment transport patterns in the vicinity of the Vaihua River mouth are to be maintained.

Response may include remedial work to permanent erosion control structures, and/or the installation of temporary control measures, where appropriate, in particular where there is potential for sedimentation of surface waters.

Controls implemented by EMPNG may be supplemented by controls undertaken by the service provider, under direction from EMPNG.

13.3 New disturbance

Where operations and/or maintenance activities involve new or additional disturbance of land (beyond the already disturbed footprint), the area to be disturbed will be assessed with respect to erosion and sedimentation potential, which at a minimum will consider:

- the type of soil (e.g. weak soils, acid sulphate soils)
- terrain evaluation
- location of surface waters and drainage lines
- existence of past instabilities (e.g. areas filled during previous works).

For areas to be cleared/disturbed, site-specific erosion and sediment controls will be implemented, which as a minimum, will include the following measures:

- assess and establish erosion and sediment control requirements (particularly in relation to site preparation earthworks, site access, site drainage, spoil management, watercourse crossings, in-stream surface water works, watercourse diversions), in accordance with industry good practice (for example International Erosion Control Association guidelines), detailing specific erosion and sediment controls to be implemented and maintained (e.g. diversion drains, sediment ponds and fabric silt curtains)
- route ROWs, access ways and spoil management areas to avoid erosion-prone areas and reduce the number of watercourse crossings, where practicable
- restrict site clearing and incidental site disturbance as far as practical by demarcating areas that require clearing and by confining traffic to designated tracks and laydown areas

- use land-clearing techniques that preserve rootstock of removed vegetation in the ground, and where possible, trim riparian trees rather than whole tree removal
- storage of topsoil, discarded vegetation and rocks, pebbles from water courses where possible for later reuse in reinstatement
- minimise the period surfaces are exposed to rainfall-based erosion and scour, and reinstate areas no longer required with priority given to areas prone to erosion
- reduce disturbance of natural drainage channels and avoid blocking channels with material
- install diversion drains to intercept uncontaminated surface run-off around facilities and away from disturbed areas where necessary
- control sediment run-off from stockpiles and cleared areas by installing control structures to intercept sediment-laden surface run-off to reduce sediment delivery to surface waters
- installation of erosion control structures to prevent subsidence
- control of potential scouring at culverts through drainage and energy dissipation devices, such as rock mattresses or gabions
- stabilise disturbed batter slopes and cleared banks to facilitate reinstatement
- monitoring of erosion and sediment control structures (including stockpiled soil) until adequate stabilisation, sediment control and subsidence control has been achieved.

Additional measures that shall be adopted as necessary to minimise erosion and sediment at watercourse crossings and/or work areas adjacent to surface waters, include:

- assess and establish erosion and sediment control measures requirements in accordance with industry good practice (for example International Erosion Control Association guidelines), detailing specific sediment and erosion controls to be implemented and maintained at watercourse crossings
- the design and construction of watercourse crossings will consider hydraulics, stability and potential flow disruptions of surface waters and fish migration
- culvert designs will accommodate flows and mitigate potential sedimentation and debris blockages
- maintain pipeline ROWs and access way alignments to watercourse crossings as close to right angles as possible to limit disturbances to the banks
- grade the ROW and access way alignments adjacent to watercourses away from surface waters
- limit watercourse crossings in areas of high, unstable banks
- limit the clearing of riparian vegetation to the width required to safely accommodate ROW, access ways and watercourse crossings
- minimise the number of watercourse crossings to limit riparian soil erosion and sediment delivery to surface waters
- time surface water works during periods of low flow, and limit the duration of in-stream construction activities
- remove trees, debris or soil inadvertently deposited below the high water mark of surface waters where safe to do so and in a manner that reduces disturbance of the bed and banks
- maintain a minimum of 10-metre vegetation buffer zone from surface waters and avoid stockpiling spoil and/or topsoil materials close to surface waters (i.e. maintaining a minimum of 10 metres from waterline)
- avoid placement of fill material in surface waters
- monitor erosion at reclaimed watercourse crossings and remediate as necessary.

14.0 REINSTATEMENT AND REGENERATION

EMPNG's objectives are to promote regeneration of temporary work areas disturbed during construction and achieve vegetation succession according to established benchmarks.

Land disturbed for temporary facilities and infrastructure, along with land in the immediate vicinity of the LNG Plant and Marine Facilities, was reinstated following construction. The overall objective of the construction phase reinstatement program was to establish stable landform conditions and create ground conditions conducive to natural regeneration. Reinstatement works included measures to control erosion and sedimentation and facilitate regeneration.

Measures to inspect and maintain permanent reinstatement works and reinstatement measures associated with new disturbance of land are described in the following sections.

14.1 Access control

Access to regenerating areas will be restricted where practical to prevent disturbance of regenerating areas and enable natural regeneration of vegetation.

Public access to areas leased by EMPNG will be discouraged using means including surveillance, physical barriers, education and/or awareness, as a means to reduce encroachment on regenerating areas.

14.2 Inspection

EMPNG will conduct inspections of regenerating areas to observe status of reinstatement and regeneration.

Where public use is identified, EMPNG will engage with the relevant party/parties in an endeavour to achieve the necessary access control. It should be recognised that remedy may not be readily achievable and beyond EMPNG's ability to control.

14.3 Maintenance and remedial action

EMPNG will use a risk-based approach to determine whether remedial action is required to address poor reinstatement and regeneration performance. Risk screening will be undertaken to identify relevant risks and identify appropriate remedial measures.

Remedial action may be readily achievable and within EMPNG's control. In such cases, remedial action, including assisted regeneration where appropriate, will be undertaken, with support from third party specialists and contractors as needed.

Certain circumstances may hinder EMPNG's ability to control outcomes, for example where neighbouring communities continue to unlawfully access regenerating areas. In these situations, EMPNG will engage with the relevant party/parties and endeavour to achieve desired outcomes.

14.4 New disturbance

Where operations and/or maintenance activities involve new or additional disturbance of land (beyond the construction footprint), site-specific reinstatement controls will be implemented, which as a minimum, will include the following measures:

- storage of topsoil for use in subsequent reinstatement
- storage of cleared vegetation for use in subsequent reinstatement
- storage of rocks, pebbles and gravel from watercourses where applicable for subsequent reinstatement
- use of land-clearing techniques which preserve vegetation root and seed stock to facilitate natural regeneration
- spread topsoil, mulch and discarded vegetation debris (including natural seed stock) on reclaimed or rehabilitated disturbed land surfaces to facilitate natural revegetation

- use of soil, mulch and vegetation to facilitate natural regeneration
- de-compaction and ripping of disturbed areas to enable seed penetration and promote natural regeneration
- prompt reinstatement of land and watercourses, reducing the time surfaces are exposed
- establishment of stable landforms and ground conditions conducive to natural regeneration
- active works to re-establish vegetation in areas that may be slow or difficult to regenerate naturally, difficult to stabilise or prone to erosion.

15.0 INVASIVE SPECIES

EMPNG's objectives are to prevent invasive species (i.e. priority weeds and pests) from entering or becoming established in or in the vicinity of EMPNG's facilities and infrastructure; and contain existing priority invasive species already present.

Measures to prevent, mitigate or otherwise control potential environmental impacts associated with invasive species are described in this section.

15.1 Identification

Weeds are categorised according to their potential for environmental harm and hence priority for management, as shown in Table 15-1.

Table 15-1: Categorisation of invasive species

PRIORITY	DESCRIPTION
Priority 1	Exists in the natural environment but has the ability to suppress and displace most native species especially in new disturbed areas.
Priority 2	Exists in the natural environment but has the ability to become locally dominant with potential to outcompete some native species.
Priority 3	Exists in the natural environment with the potential to proliferate in new disturbed areas.

Details of invasive species (i.e. both priority weeds and pests) identified in EMPNG's area of operations; including categorisation, location and degree of occurrence; are included in a register.

To facilitate identification and management, details of Priority 1 and Priority 2 weeds, including photographs and appropriate control measures, are included in a weed identification manual.

15.2 Management and monitoring

Based on the occurrence, distribution and trends of invasive species in the area of EMPNG's operations, weed management zones have been established. For each management zone, specific management and monitoring priorities are established.

Weed management zones relevant to this EMP are summarised in Table 15-2.

Table 15-2: LNG Plant and Marine Weed Management Zone

ECOLOGICAL UNIT	OBJECTIVES
Riparian	Control Priority 1 weed species Conduct surveys to monitor occurrence and distribution
Grassland	
Coastal	

EMPNG will conduct inspections in and around the immediate vicinity of the LNG Plant and Marine Facilities. The presence of priority weeds will be checked as part of the inspections in accordance with the priorities established in the weed management zones. Inspections focus on the potential occurrence of previously unrecorded species and the potential expansion or increase in abundance. Priority classifications for weeds are also reviewed and updated where supported by monitoring results and increased scientific knowledge. Refer to the invasive species register for the latest priority classifications.

Other invasive species (i.e. pests) are monitored in the EMPNG's area of operations. Inspections will focus on the potential occurrence of previously unrecorded species and their potential expansion. Results of these inspections are included in the invasive species register.

Further mitigation measures undertaken to prevent the introduction and spread of priority weeds during operations and/or maintenance activities include:

- limiting work vehicles and machinery to designated access and worksites
- prohibiting the washing of equipment, vehicles or machinery near or within watercourses
- prohibiting the establishment of gardens with introduced plant species (unless approved by EMPNG for landscaping purposes), and the introduction of exotic plants or animals by EMPNG staff and contractors.

15.3 Remedial action

Where intervention is required in accordance with the priorities established in the areas of operations for pests and/or weeds, EMPNG will implement invasive species controls, which may include physical removal, trapping, slashing (cut stump), mulching and/or application of EMPNG approved herbicides where considered to be most effective control/s.

The occurrence, distribution and trends of invasive species in the area of EMPNG's operations are subject to a periodic assessment by an independent expert advisor. As part of these assessments, the advisor will provide recommendations for the remedy of any identified problems and update the invasive species management zones as appropriate.

15.4 New disturbance

Invasive species within and in the immediate vicinity of the LNG Plant and Marine Facilities were identified as part of the environmental pre-construction survey program undertaken during construction. Site-specific mitigation and management measures were specified to avoid the spread of weeds. Where operations and/or maintenance activities involve new or additional disturbance of land (beyond the construction footprint), the environmental pre-construction survey report will be reviewed to determine if any site-specific hygiene and other mitigation measures were developed for the area to be disturbed.

15.5 Quarantine

EMPNG has adopted quarantine requirements that aim to prevent the importation and spread of foreign invasive species, pathogens or disease.

While responsibility for quarantine control rests with the Papua New Guinean National Agriculture Quarantine and Inspection Authority, EMPNG's quarantine requirements are designed to ensure that National Agriculture Quarantine and Inspection Authority requirements and international good practice for the import of goods are followed.

Requirements include avoidance of prohibited packaging materials, International Standards For Phytosanitary Measures No. 15 treatment and stamping for all timber packaging, cleaning of shipping containers at point of origin and maintenance of all necessary documentation to verify quarantine hygiene.

Suppliers and importers of goods directly and solely for EMPNG are required to inspect cargo, containers and break-bulk cargo at the point of origin on the basis of perceived risk, and, accordingly, ensure quarantine hygiene measures, such as cleaning and fumigation, are applied as necessary to containers, container contents and break-bulk cargo (which must be as clean as new) at point of origin.

EMPNG will follow International Maritime Organization requirements and industry good practice with respect to ballast water discharge and hull cleaning to prevent the introduction of invasive species.

EMPNG may, at its discretion, audit suppliers and importers of goods.

Quarantine requirements are further described in the quarantine procedure.

16.0 ECOLOGY

EMPNG's objective is to avoid impacts to specific features of ecological importance.

Disturbance and/or harassment of wildlife, hunting of fauna, possession of hunting and fishing equipment, gathering of plants or bush foods, collection of firewood, possession of wildlife products, and disturbance of migratory species habitats by EMPNG staff and contractors is prohibited.

Speed limits are implemented on EMPNG controlled roads and access ways to reduce vehicle collisions with wildlife.

Ecological sensitivities (e.g. sandalwood trees, mangroves) within and in the immediate vicinity of the LNG Plant and Marine Facilities were identified as part of the environmental pre-construction survey program undertaken during construction. Site-specific mitigation and management measures were adopted to avoid and otherwise mitigate potential impacts where feasible.

Measures to monitor the condition of sensitive ecological features within and in the vicinity of the LNG Plant and Marine Facilities and prevent impacts to these features are described in this section.

It should be noted that direct impacts to sensitive ecological features during normal operations are expected to be negligible.

16.1 Inspection

Details of ecological sensitivities within and in the vicinity of the LNG Plant and Marine Facilities are included in a register.

EMPNG will conduct inspections to check the condition of sensitive ecological features and determine the significance of any change to the condition of the ecological sensitivity.

16.2 Remedial action

Where problems are noted, EMPNG will determine appropriate mitigation measures, in consultation with an independent expert advisor where needed.

Certain circumstances may hinder EMPNG's ability to control outcomes, for example where landowners insist on access to an ecological feature. In these situations, EMPNG will engage with the relevant party/parties and endeavour to achieve desired outcomes.

16.3 New disturbance

Where operations and/or maintenance activities involve additional disturbance of land consideration will be given to the findings and mitigation measures outlined in the environmental pre-construction survey conducted for the site. Key mitigation measures that will need to be considered as appropriate include:

- avoid where practicable environmental sensitivities identified during the pre-construction survey (e.g. migratory bird habitats, mangroves, sandalwood trees)
- demarcate on technical drawings and in the field the extent of vegetation to be cleared and ensure that works and machinery do not exceed the approved disturbance footprint
- retain large trees (i.e. greater than 1m diameter breast height) when they are situated along worksite borders or where work can be undertaken around these trees, unless an exception is approved by EMPNG
- use tree felling methodologies (e.g. directionally felling) to reduce damage to adjacent vegetation and limit scraping of standing tree trunks by machinery
- maintain adequate surface flows and avoiding redirection of stream flows where practical
- patrol open trenches to rescue and record any fauna that fall within

- locate ROW, access ways and facilities within or adjacent to existing disturbed areas, where practicable
- reduce the number of special vehicle parks, and place in areas of existing disturbance, where practicable.

17.0 CULTURAL HERITAGE

EMPNG's objectives are to avoid impacts to cultural heritage sites, including archaeological and oral tradition sites and to manage cultural heritage sites in consultation with landowners.

Cultural heritage sensitivities within and in the immediate vicinity of the LNG Plant and Marine Facilities were identified as part of the PNG LNG EIS and the environmental pre-construction survey program undertaken during construction. Site-specific mitigation and management measures were adopted to avoid and otherwise mitigate potential impacts where feasible.

Aemakara and Konekaru are two cultural heritage sites of significance that were identified within the lease boundaries of the LNG Plant and Marine Facilities. Access control zones have been established around these sites and disturbance of these sites is to be avoided (Figure 17-1).

Measures to monitor the condition of cultural heritage sensitivities in the vicinity of the LNG Plant and Marine Facilities and prevent impacts to these features are described in this section.

Direct impacts to cultural heritage sensitivities during normal operations are expected to be negligible.

17.1 Inspection

Details of cultural heritage sensitivities in the vicinity of the LNG Plant and Marine Facilities are included in a register. EMPNG will conduct inspections to check the condition of cultural heritage sensitivities.

17.2 Remedial action

Based on the results of inspections, and where issues are noted, EMPNG will determine appropriate mitigation measures in consultation with landowners and where appropriate with the Papua New Guinea National Museum and Art Gallery and qualified archaeologists or other practitioners.

Where intervention is required and is within EMPNG's control, intervention will be undertaken by qualified archaeologists supported by EMPNG as needed.

Certain circumstances may hinder EMPNG's ability to control outcomes, for example where landowners insist on access to a cultural heritage site. In these situations, EMPNG will engage with the relevant party/parties and endeavour to achieve desired outcomes.

17.3 New disturbance

Where production activities involve new or additional disturbance of land (beyond the construction footprint), a pre-disturbance survey of the area to be affected will be undertaken. As part of the pre-disturbance survey, the existence of cultural heritage sensitivities will be determined by qualified archaeologists in possession of appropriate investigation permits obtained from the National Museum and Art Gallery. Site-specific mitigation and management measures will be developed, in consultation with landowners, to avoid and/or otherwise mitigate impacts to identified cultural heritage sensitivities.

In general, the following mitigations will apply, tailored as appropriate to the site-specific circumstances.

Sensitive sites identified by landowners as requiring protection will be avoided in all cases, access thereto prohibited and appropriate access control zones established.

Burial sites located within or close to a proposed area of disturbance will be avoided where possible, and if they cannot be avoided, will be moved prior to disturbance. In such cases, EMPNG will obtain prior consent from landowners or clan representatives for the relocation and agree responsibility for burial relocation. At the request of landowners or clan representatives, EMPNG will be responsible for the relocation. Should the burials located within the proposed area of disturbance be identified by landowners or clan representatives

as being particularly sensitive and requiring protection, they will be avoided, with access prohibited and appropriate access control zones established.

Spirit and other ceremonial sites located within or close to a proposed area of disturbance will be avoided where possible. If they cannot be avoided, EMPNG will consult with landowners or clan representatives to agree the appropriate mitigation measures, for example, spirit moving ceremony. Should the spirit and other ceremonial sites located within the proposed area of disturbance be identified by landowners or clan representatives as being particularly sensitive and requiring protection, they will be avoided, with access prohibited and appropriate access control zones established.

Archaeological sites located within or close to a proposed area of disturbance will be avoided where possible. If they cannot be avoided, EMPNG will consult with landowners and the National Museum and Art Gallery to determine requirements for mitigation.

New disturbance has the potential to affect as yet unknown or unrecorded archaeological sites. These unknown archaeological sites, including skeletal remains, discovered during archaeological salvage or construction activities are referred to as chance finds. In addition to the site-specific measures discussed, EMPNG will implement a chance finds process to enable preservation and appropriate treatment of chance finds. A level of significance is assigned to each find (low, medium, and high significance, and burial with skeletal items) which guides the management and documentation of the find. Where a find is deemed to be of high significance and/or a burial with skeletal items, salvage protocols are applied in accordance with consultation with the National Museum and Art Gallery.

Details of the cultural heritage management program are provided in the cultural heritage management procedure. The chance finds process is documented in the archaeological chance finds procedure. The salvage process is documented in the archaeological salvage procedure.

17.4 Management of salvaged archaeological material

Archaeological salvage undertaken during construction was completed in accordance with the terms of the Permit for Investigation and Salvage Protocol (LNG Plant) issued by National Museum and Art Gallery on 26 August 2009.

The salvage process and the cultural material obtained from the salvage is documented and described in the *Final Report on the Archaeological Salvage Excavations at the PNG LNG Facilities Site and Bypass Road Corridor (Monash University, 2011)* and all cultural material has been transferred to the National Museum and Art Gallery pursuant to the requirements of the *National Cultural Property (Preservation) Act 1965.*

Cultural heritage material recovered as part of any salvage work undertaken during production will be managed in consultation with National Museum and Art Gallery and in accordance with the terms of the Permit for Investigation and Salvage Protocol (LNG Plant) and the *National Cultural Property (Preservation) Act 1965.*

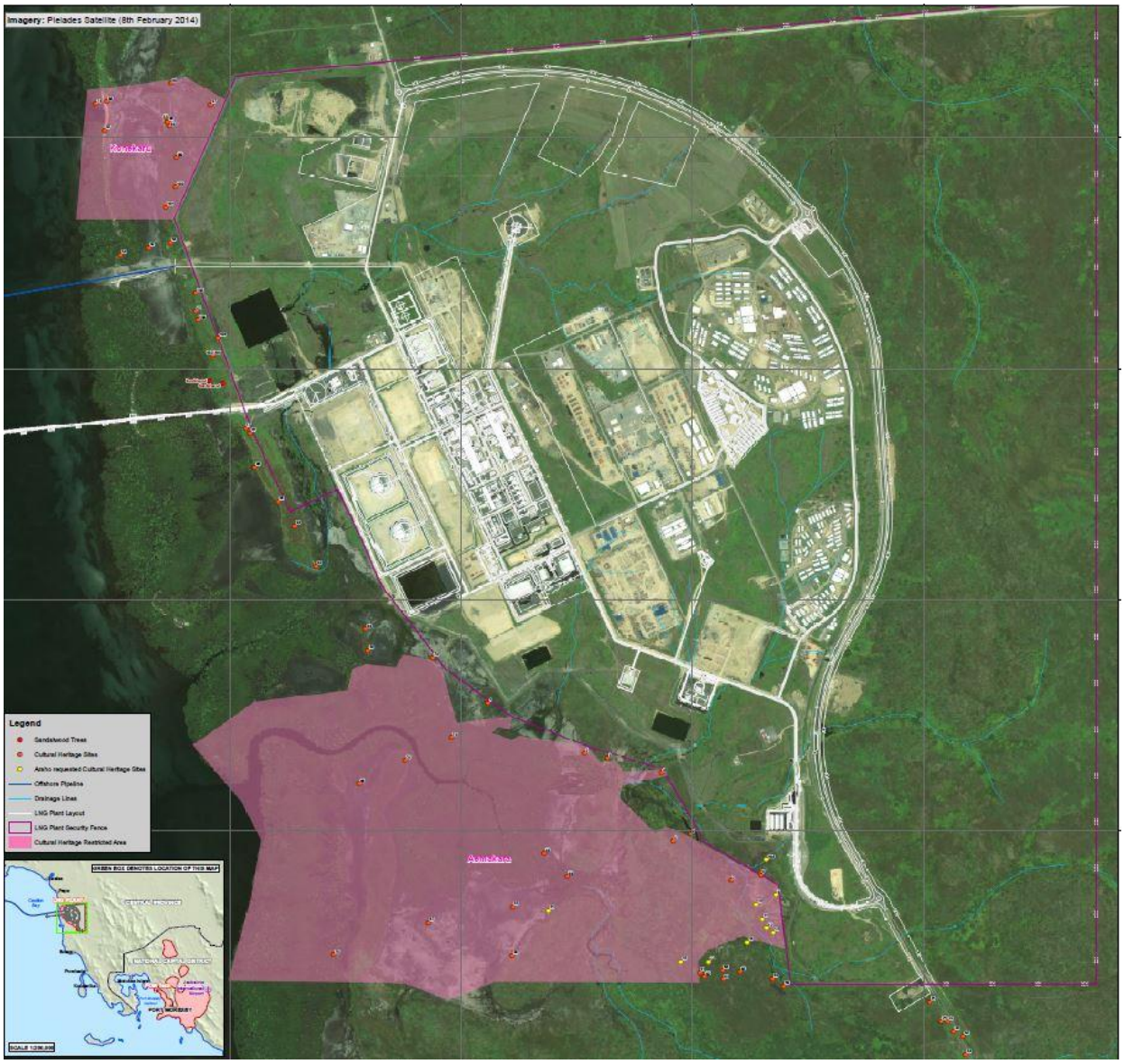

Figure 17-1: Konekaru and Amekara restricted access areas

18.0 ENVIRONMENTAL MONITORING

The environmental monitoring program for production is described in this section. For the purposes of this EMP, environmental monitoring does not include the processes of verification, inspection, assessment and audit, which are discussed in Section 19.0.

The monitoring measures outlined have been developed in accordance with the requirements of, and using the methods prescribed in OIMS System 6-5 Environmental Management. Monitoring data collected as part of the objectives of this EMP may also contribute to EMPNG's Biodiversity Implementation and Monitoring Program.

18.1 Monitoring of emissions to air

Monitoring of emissions to air from relevant emission sources at the LNG Plant and Marine Facilities is outlined in Table 18-1.

Table 18-1: Monitoring of emissions to air

FACILITY	PARAMETER	EMISSION GUIDELINE VALUE	SUMMARY	FREQUENCY**
Compressor gas turbines/WHRU	Oxides of nitrogen	25 ppm	Stack test	Note 1
Main power generators	Oxides of nitrogen	42 ppm	Stack test	Note 1
Process waste incinerator	PM	70 mg/m^3	Stack test	Note 1
	Carbon monoxide	157 ppm	Stack test	Note 1
	Oxides of nitrogen	388 ppm	Stack test	Note 1
	Oxides of sulphur	20 ppm	Stack test	Note 1
	Hydrogen chloride	62 ppm	Stack test	Note 1
	Cadmium	0.004 mg/m^3	Stack test	Note 1
	Lead	0.04 mg/m^3	Stack test	Note 1
	Mercury	0.47 mg/m^3	Stack test	Note 1
	Dioxin/furan	0.41 ng/m^3	Stack test	Note 1
	Opacity	10 percent	Visual observation	Daily
General waste incinerator	PM	270 mg/m^3	Stack test	Note 1
	Carbon monoxide	13 ppm	Stack test	Note 1
	Oxides of nitrogen	170 ppm	Stack test	Note 1
	Oxides of sulphur	1.2ppm	Stack test	Note 1
	Hydrogen chloride	200 ppm	Stack test	Note 1
	Cadmium	0.67 mg/m^3	Stack test	Note 1
	Lead	2 mg/m^3	Stack test	Note 1
	Mercury	0.0035 mg/m^3	Stack test	Note 1
	Dioxin/furan	31 ng/dscm	Stack test	Note 1
	Fugitive ash	Visible emissions for no more than 5 percent of the hourly observation period.	Visual observation	Daily

FACILITY	PARAMETER	EMISSION GUIDELINE VALUE	SUMMARY	FREQUENCY**
Source (compressor gas turbines/WHRU and main power generators): *Environmental, Health, and Safety General Guidelines (IFC, 2007),* Table 1.1.2 - Small Combustion Facilities Emissions Guidelines. Source (process waste incinerator): Based on *Title 40 – Protection of Environment, Part 60 – Standard of Performance for New Stationary Sources [40 CFR 60] (United States Environmental Protection Agency, 2008)*, Subpart CCCC (Standards of Performance for Commercial and Industrial Solid Waste Incineration Units), including threshold for applicability relating to throughput, as referenced in *Environmental, Health and Safety Guidelines for Waste Management Facilities (IFC, 2007)*. Source (general waste incinerator): Based on *Title 40 – Protection of Environment, Part 60 – Standard of Performance for New Stationary Sources [40 CFR 60] (United States Environmental Protection Agency, 2008)*, Subpart CCCC (Standards of Performance for Commercial and Industrial Solid Waste Incineration Units), Table 8- Emission Limitations for Small, Remote Incinerators That Commenced Construction After June 4, 2010, Or That Commenced Reconstruction or Modification After August 7, 2013 Emission guideline values apply during normal steady state operations, and not startup, shutdown and abnormal operations. Emission guideline values for dioxin/furan at toxic equivalency basis. Compressor gas turbines/WHRU and main power generator parameters are stated at reference conditions of 15 percent oxygen, dry gas. Incinerator parameters are stated at reference conditions of 7 percent oxygen, dry basis at standard conditions. **Note 1: Stack testing will be undertaken twice yearly for the first two years of operation. Thereafter, for each emission source, monitoring frequency and scope can be reduced such that: • Stack testing is conducted every three years if monitoring results meet the required criteria; or annually if not until compliance is achieved, and • A representative selection of air emission sources is included in each stack testing program.				

Emissions monitoring consists of periodic stack sampling undertaken on behalf of EMPNG by a competent specialist in accordance with standard industry methods and subject to the provisions set out in the stack emissions monitoring procedure.

18.2 Monitoring of ambient air quality

Monitoring of ambient air quality will be undertaken periodically in the vicinity of the LNG Plant and Marine Facilities to validate the predictions of the ambient air quality assessments (see Section 7.0) and evaluate conformance with the guideline values outlined in Table 7-1.

An initial monitoring campaign was undertaken when the facility achieved steady state operations. Further ambient air quality monitoring will be conducted after major modifications to existing plant that will increase emissions affecting ambient air quality. Ambient air quality monitoring will be conducted on behalf of EMPNG by a competent specialist in accordance with standard industry methods. The focus of ambient air quality monitoring will be sensitive community receptors identified as part of baseline air quality assessments and dispersion modelling exercises.

18.3 Monitoring of noise

Monitoring of noise will be undertaken periodically at the lease boundary of the LNG Plant (in line with sensitive receptors in the vicinity of the LNG Plant), and/or at the nearest sensitive receptors outside the LNG Plant's lease boundaries to evaluate conformance with the guideline values in Table 8-1. Monitoring will be undertaken in accordance with the method set out in the noise monitoring procedure.

18.4 Monitoring of water abstraction

The volume of water abstracted from each surface water abstraction point (e.g. sea water) is recorded and details maintained in a register. Monitoring of abstraction volumes will be

undertaken where appropriate (i.e. where prior environmental assessment has determined the need for monitoring).

18.5 Monitoring of discharges to water

Monitoring of stormwater discharges from the LNG Plant consists of period in-situ sampling of the parameters shown in Table 9-6. Monitoring will be undertaken in accordance with the method set out in the stormwater monitoring procedure.

Monitoring of discharges from the retention pond consists of periodic in-situ sampling of the parameters shown in Table 9-7. Monitoring will be undertaken in accordance with the method set out in the effluent monitoring procedure.

Monitoring of discharges from the oily wastewater treatment system will consist of periodic insitu sampling of parameters shown in Table 9-8. Monitoring will be undertaken in accordance with the method set out in the effluent monitoring procedure.

Monitoring of discharges from the WWTP treating sewage and landfill leachate at the LNG Plant consists of periodic in-situ sampling of the parameters shown in Table 9-9**Error! eference source not found.**. Monitoring will be undertaken in accordance with the method set out in the WWTP effluent monitoring procedure.

The criteria referenced in the above tables are considered applicable based on EMPNG's understanding of discharge types and their respective constituents. In order to determine those parameters relevant to the discharges, EMPNG will undertake initial monitoring campaigns during the first two years of production covering the full range of parameters prescribed in the *Environment (Water Quality Criteria) Regulation 2002*. Thereafter, only relevant parameters will be monitored.

For the purposes of monitoring, the criteria shown in Table 9-6 (stormwater), Table 9-7 (LNGP retention pond), Table 9-8 (oily wastewater treatment system), and Table 9-9 (WWTP) are deemed by EMPNG to apply end of pipe (at the discharge location) and not in the receiving water body. Should monitoring indicate that any of the criteria have not been met end of pipe, monitoring shall be undertaken in the receiving water body, where feasible, in order to evaluate compliance with the *Environment (Water Quality Criteria) Regulation 2002*.

18.6 Monitoring of surface water quality

Monitoring of marine water quality will be undertaken periodically at several locations in the vicinity of the marine outfall. Parameters to be monitored are shown in Table 9-2. Monitoring will be undertaken in accordance with the method set out in the marine water quality monitoring procedure.

Monitoring of freshwater quality in the Vaihua River will be undertaken at the discretion of EMPNG.

18.7 Monitoring of groundwater quality

Monitoring of groundwater quality in the vicinity of the LNG Plant landfill consists of periodic grab samples of the parameters shown in

Table 18-2.

Samples will be taken at one up-gradient well, two cross-gradient wells and two down-gradient wells relative to the production landfill cells, in accordance with the method set out in the groundwater monitoring procedure.

Table 18-2: Monitoring of groundwater

PARAMETER	GUIDELINE VALUE	SUMMARY
pH	No alteration above site background ranges	Grab sample at one up-gradient well, two cross-gradient wells and two down-gradient wells (relative to the landfill cell). Conducted every six months.
Dissolved oxygen		
Sulphate		
Ammonia-nitrogen		
Nitrates		
Major ions (calcium, magnesium, sodium, potassium)		
Electrical conductivity		
Arsenic		
Barium		
Boron		
Cadmium dissolved		
Chromium (as hexavalent)		
Cobalt		
Copper		
Iron (dissolved)		
Lead		
Manganese (dissolved)		
Mercury		
Nickel		
Selenium		
Silver		
Tin		
Zinc		
Total petroleum hydrocarbons		
Faecal coliforms		
Phenols		
Source: Annex 2 of the Environment Permit, based on *Environment (Water Quality Criteria) Regulation 2002*, Water Quality Criteria for Aquatic Life Protection.		

18.8 Monitoring of freshwater ecology

Monitoring of ecological conditions of the Vaihua River will be undertaken at the discretion of EMPNG.

18.9 Monitoring of marine ecology

Monitoring of ecological conditions in Caution Bay will be undertaken at the discretion of EMPNG.

18.10 Non-conformance and corrective action

Non-conformances identified through the environmental monitoring program will be tracked using an action tracking system. The action tracking system includes details of all environmental non-conformances, the remedial/corrective action(s) required, responsible parties assigned to actions/timings and the status of the remedial/corrective action(s).

19.0 ASSESSMENT AND AUDIT

Processes for environmental verification, inspection, assessment and audit are described in this section. The processes have been developed in accordance with the requirements prescribed in OIMS System 1-1 Management Leadership, Commitment and Accountability, OIMS System 6-5 Environmental Management and OIMS System 11-1 OIMS Assessment and Improvement.

19.1 Verification and inspection

EMPNG will undertake a field-based verification and inspection program to evaluate environmental aspects, verify and document the implementation, and in some cases the effectiveness, of environmental controls set out in this EMP.

The verification and inspection program will be undertaken by EMPNG in accordance with a pre-determined procedure that sets out the methods, frequency and scope of inspections. Frequency of inspections will be determined on the basis of need and environmental risk, but in general inspections will be carried out on a daily, weekly, monthly or quarterly basis as appropriate.

The procedure will be periodically reviewed and adapted in response to inspection results, changing circumstances and lessons learned (for example practicality, interpretability and usefulness).

The field-based verification and inspection program will be documented in a register that includes details of the inspections undertaken and a summary of the findings and results.

The verification and inspection program is outlined in Table 19-1.

19.2 Assessment

EMPNG will undertake assessments to evaluate environmental aspects, verify and document the implementation, and in some cases the effectiveness, of environmental controls set out in this EMP. This involves an internal assessment, evaluating performance across a subset of aspects which occurs on a nominated frequency, with the completion of an evaluation of all aspects listed in the EMP after five years.

In addition to the above, OIMS assessments will be undertaken in accordance with OIMS System 11-1 OIMS Assessment and Improvement, to evaluate the degree to which OIMS requirements are met as part of the implementation of this EMP.

In addition to periodic assessments, EMPNG may conduct targeted assessments in response to particular circumstances.

Facilities and operations of third party suppliers of fuel and chemicals are subject to prior assessment and approval, as are facilities and operations of third party suppliers of aggregate and quarry material and third party suppliers of timber. Third parties and third party facilities receiving EMPNG waste are subject to prior assessment and approval. EMPNG may undertake assessments of other third party facilities and providers, as relevant to this EMP.

Assessments undertaken by EMPNG will be documented in a register including details of the assessments and a summary of the findings and results. EMP assessment results may also contribute to EMPNG's Biodiversity Implementation and Monitoring Program.

Table 19-1: Verification and inspection

ASPECT/CONTROL	GENERAL SCOPE OF VERIFICATION/INSPECTION
Emissions to air	• Visual inspection of flares • Stack emissions monitoring results • Continuous emissions monitoring system results • Incinerator operating conditions and combustion temperatures • Visual inspection of diesel engines • Diesel engine maintenance records • Fugitive emissions estimations • Inspection of direction of perimeter and other lighting • Greenhouse gas emissions tracking
Ambient air quality	• Ambient air quality monitoring results
Noise	• Noise monitoring results • Notification to affected communities of planned high intensity noise events
Discharges to water	• Visual inspection of water systems and discharge location • Visual inspection of WWTP discharges • WWTP operating conditions • Discharge monitoring results
Spill prevention and response	• Incident registers • Assessment reports from third party fuel and chemical transporters' activities • Inspection of fuel and chemical storage facilities • Fuel and chemical transfer facilities and operations • Spill response equipment
Materials management	• Registers • Prohibited substances • Hazardous materials controls and Material Safety Data Sheets • Register of water abstraction • Water abstraction locations • Third party supply of aggregate and quarry material • Third party supply of timber
Waste	• Registers • Waste avoidance and minimisation rates • Waste collection areas and process inspections • Waste storage areas and process inspection • Waste reuse, recycling and recovery rates • Inspections of waste transfer to third parties • Waste treatment areas and process inspections • Waste incineration area and process inspections • Ash stabilisation, including laboratory results • Landfill area and process inspections • Leachate collection and treatment process inspections • Waste tracking documentation
Erosion and sediment	• Condition of erosion control works • Condition of surface waters • Inspection of activities involving new disturbance

ASPECT/CONTROL	GENERAL SCOPE OF VERIFICATION/INSPECTION
Reinstatement and regeneration	• Condition of reinstatement works/devices • Status of reinstatement and regeneration • Inspections of encroachment of regenerating areas • Inspection of activities involving new disturbance
Invasive species	• Registers • Weed identification manual availability • Presence of new invasive species to the worksite • Increase in existing invasive species within the worksite
Ecology	• Register of ecological sensitivities • Condition of ecological sensitivities • Inspection of activities involving new disturbance
Cultural heritage	• Registers • Condition of cultural heritage sensitivities • Inspection of activities involving new disturbance

19.3 Audit and review

The Independent Environmental and Social Consultant (IESC), on behalf of the Lender Group, will undertake an annual review of the environmental aspects set out in this EMP.

Co-venture parties may undertake environmental audit of the environmental aspects controls set out in this EMP.

CEPA may undertake environmental audit of the environmental aspects controls set out in this EMP.

Audits undertaken by external parties will be documented using a register that includes details of the audits and a summary of the findings and results.

19.4 Non-conformance and corrective action

Non-conformances identified through the field-based verification and inspection program, assessments and audits will be tracked using an action tracking system. The action tracking system includes details of all environmental non-conformances, the remedial/corrective action required, actions/timings assigned to responsible parties and status of the remedial/corrective action.

19.5 Performance indicators

In accordance with OIMS System 6-5 Environmental Management, EMPNG will steward environmental performance data through the use of performance indicators.

Performance indicators relevant to this EMP are shown in Table 19-2.

The performance indicators will be periodically compiled using data collected from the registers and monitoring, verification, assessment and audit processes described in this EMP.

Table 19-2: Performance indicators

ASPECT	OBJECTIVE	INDICATOR	MEASUREMENT NOTE 1
Emissions to atmosphere and ambient air quality	Avoid significant impacts associated with the release of pollutants to the atmosphere	Occurrence of significant impacts to air quality/atmosphere	Number
	Meet applicable stack test emissions criteria	Exceedance of stack test emissions criteria	Total number of air quality related non-conformances and location
	Meet applicable ambient air quality criteria	Exceedance of ambient air quality criteria	Total number of ambient air quality related incidents and location
Noise	Avoid significant noise and vibration impacts to community and fauna	Noise and/or vibration related grievances	Number
	Meet applicable noise criteria	Exceedance of noise criteria	Number
Discharges to water	Avoid significant impacts associated with the release of pollutants to surface water and groundwater	Water quality within the natural surface water and/or groundwater shall not exceed applicable criteria	Total number of water quality related incidents and location
	Meet applicable discharge criteria	Exceedance of discharge criteria	Total number of water quality related non-conformances, location
Spill prevention and response	Prevent spills of hydrocarbons, chemicals and untreated sewage	Release of hydrocarbons, chemicals, and/or untreated sewage to the environment	Type and number* *Only environmental spills are included in this performance indicator. (Gaseous releases to atmosphere are not included)
	Respond quickly and effectively to spills should they occur		
Materials management	Avoid significant impacts associated with the procurement and use of raw materials.	Use of chemicals and/or hazardous materials subject to international bans or phase-outs	Number and reason
	Use materials that are less hazardous or otherwise preferable from an environmental perspective, where practical		
Waste	Apply the waste management hierarchy		Percent

ASPECT	OBJECTIVE	INDICATOR	MEASUREMENT NOTE 1
	Manage and dispose of waste at EMPNG facilities and approved third party facilities only	Waste managed and disposed of at EMPNG facilities and approved third party facilities only	
Erosion and sediment	Control significant erosion and prevent sedimentation of surface waters	Occurrence of significant erosion (i.e. remedial works required)	Number
		Sedimentation of surface waters	Number
Reinstatement and regeneration	Promote regeneration of vegetation in areas disturbed during construction and not required for production	Regeneration areas are achieving established regeneration benchmarks	Yes/No, reason
	Achieve established benchmarks for regeneration areas		
Invasive species	Prevent invasive species (priority weeds and/or pests) from entering or establishing in areas affected by PNG LNG	Ingress of new Priority 1 weeds and/or pests into PNG LNG worksites	Type, abundance and distribution
	Contain invasive species (priority weeds and/or pests) already established in areas affected by PNG LNG	Increases in existing Priority 1 weeds and/or pests in PNG LNG worksites.	Type, abundance and distribution
Ecology	Avoid impacts to specific features of ecological importance	Observed degradation in condition of specific features of ecological importance	Significance of change to the condition of specific ecological features
Cultural heritage	Avoid impacts to cultural heritage sites, including archaeological and oral tradition sites	Cultural heritage sites disturbed	Number
	Manage cultural heritage sites in consultation with landowners	Cultural heritage sites managed in accordance with landowner direction	Number
Note 1: 'Number' in this column refers to number of occurrences.			

20.0 INCIDENT MANAGEMENT, NOTIFICATION AND REPORTING

Environmental incidents are managed, reported and notified as outlined in this section. These processes have been developed in accordance with the requirements prescribed in OIMS System 9-1 Incident Management.

20.1 Incident management

OIMS System 9-1 Incident Management defines the incident management process to be followed by EMPNG during production, including requirements for managing environmental incidents.

For the purposes of this EMP, an incident is defined as a specific event, sequence of events, or extended condition that has an unwanted or unintended impact on the environment. EMPNG's Incident Management Manual defines types of incidents and their Severity Level.

In general, environmental incidents during production will be managed as follows:

- reduce further harm where applicable to personnel, the environment and assets
- classify the incident and notify and/or report to internal and external stakeholders as appropriate
- investigate incidents, based on their severity or potential severity, to identify causes and implement corrective actions to prevent incident recurrence
- stimulate learning opportunities by sharing lessons learned internally and externally as appropriate.

Contractors and subcontractors will adhere to EMPNG's incident management requirements.

20.2 Incident notification and reporting

All environmental incidents will be documented, notified and reported in accordance with EMPNG's Incident Management Manual, which defines requirements for managing incidents, including environmental incidents, and the method and timing required for the notification and reporting of incidents dependent upon classification of severity level.

20.2.1 Internal notification and reporting

Environmental incidents are notified and reported in accordance with the EMPNG's Incident Management Manual.

20.2.2 Statutory notification and reporting

Environmental incidents are notified to government agencies pursuant to statutory notification requirements.

It is a condition of the Environment Permit for EMPNG to promptly report to CEPA any significant environmental incidents that occur.

The Department of Petroleum and Energy is notified of significant environmental incidents pursuant to the requirements of the *Oil and Gas Act 1998* and the associated *Oil and Gas Regulation 2002*. Section 8 of the *Oil and Gas Act 1998* requires immediate notification of all incidents involving spillage of hydrocarbons in excess of 10 barrels (1600 litres).

20.2.3 Notification and reporting to IESC/Lender Group

The IESC/Lender Group is notified of environmental incidents pursuant to the requirements of the Common Terms Agreement.

Contractors and subcontractors will adhere to EMPNG's incident notification and reporting requirements.

21.0 ROLES AND RESPONSIBILITIES

Organisational roles and responsibilities relating to the implementation of this EMP are outlined in this section. These roles and responsibilities are defined in accordance with the requirements prescribed in OIMS System 1-1 Management Leadership, Commitment and Accountability, which contains requirements pertaining to the allocation of resources.

In general, and as mandated by OIMS, EMPNG will ensure sufficient resources are allocated on an ongoing basis to achieve effective implementation of this EMP. Organisational charts and individual job descriptions are periodically reviewed.

EMPNG's E&R group is allocated primary responsibility for the implementation of this EMP. In addition to the E&R group and SHE department, other EMPNG production and maintenance personnel have defined roles and responsibilities regarding this EMP. Roles and responsibilities of key personnel are outlined in Table 21-1.

Table 21-1: Roles and responsibilities

ROLE	RESPONSIBILITY
LNG Plant Manager	• Overall accountability for conformance with the requirements of this EMP pertaining to the LNG Plant and Marine Facilities • Ensure operational resources are allocated to the effective implementation of this EMP, in respect of the LNG Plant and Marine Facilities
SHE Manager	• Overall responsibility for conformance with the requirements of this EMP and Biodiversity Strategy
Logistics and Infrastructure Superintendent	• Accountable for conformance with the requirements of this EMP and other applicable requirements pertaining to the LNG Plant Waste Management Area and other services provided by Logistics • Ensure operational resources are allocated to the effective implementation of this EMP in respect of the LNG Plant Waste Management Area and other services provided by Logistics • Direct the waste service Contractor
Procurement Supervisor	• Ensure resources are allocated to the effective implementation of the quarantine procedure
E&R Supervisor	• Ensure environmental resources are allocated to the effective implementation of this EMP and Biodiversity Strategy

22.0 COMPETENCY, TRAINING AND AWARENESS

Information relating to competency, training and awareness regarding the implementation of this EMP is provided in this section. EMPNG aims to ensure that personnel involved in the implementation of this EMP have the experience, knowledge and other skills necessary to meet the requirements of their specific job functions.

The processes set out in this section have been developed in accordance with the requirements prescribed in OIMS System 5-1 Personnel Selection, Training and Competency Verification.

22.1 Competency

In accordance with OIMS System 5-1 Personnel Selection, Training and Competency Verification, EMPNG will define competency requirements for specific job functions and verify competency during personnel selection and placement.

Competency requirements for the job functions and roles involved in the implementation of this EMP will be specified and documented. Competency will be verified during personnel selection and placement to ensure that individual qualifications, knowledge and skills (namely competencies) are appropriate for the specific job requirements. Competency will also be verified on an ongoing basis through observation and performance assessments.

Where an individual does not meet all competency requirements required for his or her specific job function, appropriate training requirements are identified.

22.2 Training and awareness

In accordance with OIMS System 5-1 Personnel Selection, Training and Competency Verification, EMPNG will ensure that personnel responsible for the execution of the tasks and requirements contained within this EMP are trained, on an ongoing basis, and have the knowledge and skills necessary to meet the requirements of their specific positions.

Training and awareness associated with this EMP will be planned and documented by means of a training needs assessment, training program and training records. Training needs assessments and training programs will be reviewed periodically.

The training program will include several levels of competency and training, delivered as a function of job descriptions and individual duties, as summarised in Table 22-1.

Table 22-1: Training and awareness

TYPE OF TRAINING	DESCRIPTION
Induction	Induction is directed at visitors, providing a summary of key aspects, controls and relevant instructions. This training is specific to each location and facility.
General awareness	Awareness and overview training is provided to personnel who do not have direct duties in relation to this EMP. The training includes a summary of key environmental aspects, controls and other relevant instructions.
Management awareness	Awareness, directed at management and superintendent-level personnel, covering the key aspects of this EMP.
Job-specific training	Job-specific training, given to personnel having direct duties in respect of this EMP, providing a detailed review of specific components of this EMP and a detailed description of individual duties.

Training will consist of on-the-job training, mentoring, self-study, classroom instruction, seminars, workshops, computer-based training and practical drills, as appropriate.

22.3 Training of third parties

EMPNG will ensure that third parties and service providers have the necessary competencies through the procurement and selection process, as outlined in OIMS System 8-1 Third Party Services.

23.0 DATA MANAGEMENT

Registers and data obtained from the monitoring, verification, assessment, audit and performance indicator processes described in this EMP will be managed using an electronic information management system.

The information management system acts as a repository for data relating to this EMP and is designed to handle and manipulate data as required (for example tracking and trend analysis) to facilitate reporting.

24.0 REPORTING

24.1 Internal reporting

Summary reports concerning the implementation of this EMP will be compiled periodically as necessary for the E&R Supervisor, SHE Manager or other EMPNG management.

The summary reports will include qualitative and quantitative data, reporting against performance indicators, non-conformance and incident data, and other information as relevant.

24.2 External reporting

24.2.1 Reporting to the Conservation and Environment Protection Authority

Pursuant to the Environment Permit, EMPNG will submit periodic environmental reports to CEPA. The reports will include qualitative and quantitative data, environmental monitoring data (sampling and analysis), non-conformance and incident data (including remedial and corrective actions), reporting against performance indicators, water extraction volumes, pre-disturbance surveys undertaken in the reporting period, and other information as relevant to this EMP.

24.2.2 Reporting to the Lender Group

Pursuant to the Common Terms Agreement, EMPNG will submit an annual PNG LNG Environmental and Social Report to the Lender Group and the IESC.

The PNG LNG Environmental and Social Reports will include qualitative and quantitative data, environmental monitoring summaries (sampling and analysis), verification, assessments and audits undertaken during the reporting period, non-conformance and incident data (including remedial and corrective actions), reporting against performance indicators, notifications made to the Lender Group, pre-disturbance surveys undertaken and other information as relevant to this EMP.

25.0 REFERENCES

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26.0 APPENDICES

Appendix 1: Environmental Impact Statement mitigation measures
Appendix 2: Summary of emissions and discharges

APPENDIX 1: ENVIRONMENTAL IMPACT STATEMENT MITIGATION MEASURES

PERFORMANCE STANDARD THEME	MITIGATION MEASURE REFERENCE	MITIGATION MEASURE	EMP SECTION REFERENCE
Performance Standard 3: Pollution Prevention and Abatement Pollution Prevention, Resource Conservation and Energy Efficiency	M43, M49, M180*	Use low mono-nitrogen oxides turbines at in the LNG Plant. Turbine generators will use dry, low-emissions technology to maintain mono-nitrogen oxides and carbon monoxide concentrations at less than 25 ppm	Section 6.0
	M44*, M176	Diesel powered equipment will be regularly serviced and low-sulphur diesel used where practicable	Section 6.0
	M47	Regularly inspect and maintain valves, pipes and tanks, etc. to reduce fugitive volatile organic compound emissions	Section 18.0
	M48	WHRUs will utilise heat from the exhaust from the aero-derivative turbines driving the two propane refrigeration compressors to provide the main source of heat to the hot oil system	Section 6.0
	M96*	Manage sewage in an appropriate manner to limit contamination and protect human health	Section 9.0
	M129*	Treat effluents to appropriate standards and allow time for sediment to settle prior to discharge	Section 9.0
	M133	Operate WWTPs in accordance with the manufacturer's specifications and comply with the conditions of discharge quality specified in the Environment Permit	Section 9.0
	M29*, M134, M135*, M149*, M219*	Treat all water and wastewater discharges as necessary to comply with the prescribed conditions specified in the Environment Permit. Develop a contingency plan outlining actions to be taken should the discharge quality criteria not be met	Section 9.0
	M136	Non-equipment areas at plant facilities will be graded and sloped to allow uncontaminated stormwater to drain naturally via the stormwater drains prior to routing off-site	Section 9.0
	M150	The washing of equipment, vehicles or machinery near or within watercourses will be prohibited	Section 9.0
	M159*	Site-specific surface water and stormwater management procedures will be implemented	Section 9.0
	M164*	Develop and implement a water quality monitoring plan	Section 18.0
	M171*	Adhere to specific criteria for construction and production that are aligned to the intent of the IFC and World Health Organization guidelines. A noise limit of 55 dBA Leq (day) and 45 dBA Leq (night) from noise sourced from the operation of the facilities will apply to protect the amenity of residential landowners	Section 8.0
	M174*	Notify potentially affected persons of intended high noise intensity work and its duration	Section 8.0
	M206	Consider discharging wastewater and brine in the same vicinity to assist with salinity dilutions	Section 9.0

PERFORMANCE STANDARD THEME	MITIGATION MEASURE REFERENCE	MITIGATION MEASURE	EMP SECTION REFERENCE
Performance Standard 3: Pollution Prevention and Abatement Emergency Preparedness and Response	M25*, M148	Vehicles and machinery are to be maintained to a high level of safety with respect to leaks. Drivers will be appropriately trained and have the required driving licence	Section 0
	M27*, M209	Hydrocarbon spill prevention and response procedures will be detailed in the Oil Spill Contingency Plan and include staff training at induction to inform workers of their responsibilities under the Plan	Section 10.0
	M151	An appropriate number of staff will be trained in the handling of emergency response and spill scenarios	Section 0
Performance Standard 3: Pollution Prevention and Abatement Hazardous Materials	M26*, M30*, M130*, M146*	Fuel, lubricating oils and chemicals storage systems shall be purpose-built, located in designated above ground areas away from watercourses, and provided with secondary containment. As appropriate secondary containment will be designed to enable containment of 110 percent of the storage capacity of the largest container present	Section 0
	M99	Prohibit wash-down or fuel handling near or in streams	Section 9.0 and 15.0
	M100	Establish appropriate procedures for fuel handling transport and storage	Section 0
	M101	Establish appropriate procedures for materials handling, storage and disposal	Section 0
	M102	Establish appropriate procedures for the storage and handling of radioactive materials	Section 11.0
	M147*	Operational practices for vehicle/equipment refuelling, which includes the prevention of spillage and the use of spill containment and response equipment, are to be in place. To be included is the requirement for fuel delivery vehicles and equipment to contain spill kits and be routinely inspected so as to ensure the tank, pumps, pipe work and the vehicle itself are free from leaks and fit for purpose	Section 10.0
Performance Standard 3: Pollution Prevention and Abatement Waste	M92*	Dispose of waste to EMPNG-approved waste facilities	Section 12.0
	M95*	Establish waste management procedures to control and appropriately manage all waste	Section 12.0
	M97*, M128, M181*	Incinerate combustible waste at EMPNG approved facilities, dispose of ash to EMPNG-approved landfills	Section 12.0
	M98*	Track all wastes to be disposed or recycled	Section 12.0
	M103	Establish procedures for waste that comply with applicable parts of the *Environmental, Health, and Safety General Guidelines (IFC, 2007)* and *Environmental, Health and Safety Guidelines for Waste Management Facilities (IFC, 2007)* and meet the intent of limits in *Title 40 – Protection of Environment, Part 60 – Standard of Performance for New Stationary Sources [40 CFR 258] (United States Environmental Protection Agency, 2008)* Subpart D, as applicable	Section 6.0, Section 12.0

PERFORMANCE STANDARD THEME	MITIGATION MEASURE REFERENCE	MITIGATION MEASURE	EMP SECTION REFERENCE
	M132*	Treat and dispose of biological, pharmaceutical and medical wastes using appropriate technologies, including use of special containers, segregation and handling procedures	Section 12.0
	M188*, M210*	The storage, use and handling of all hazardous chemicals, materials and wastes on project vessels is in accordance with IMO MARPOL (1973/1978) requirements and applicable international port policies and procedures.	Section 12.0
Performance Standard 3: Pollution Prevention and Abatement Erosion and Sedimentation	M23*	Assess and establish erosion and sediment control requirements (particularly in relation to site preparation earthworks, road construction across watercourses, watercourse diversions, site drainage), detailing specific erosion and sediment controls to be implemented (e.g., diversion drains, sediment ponds and fabric silt curtains). The controls should limit the mobilization and dispersion of sediment into freshwater and estuarine environments	Section 13.0
	M32*	Limit erosion and dust effects of soil and spoil	Section 13.0
	M138*	Remove trees, debris or soil inadvertently deposited below the high water mark of watercourses where safe to do so and in a manner that reduces disturbance of the bed and banks	Section 13.0
	M140	Keep pipeline ROWs and access way alignment approaches to watercourses as close to right angles as possible to limit disturbances to the banks of watercourses, where practicable	Section 13.0
	M141*	Conduct fine-scale routing of the ROWs, access ways and spoil management areas to avoid erosion-prone areas, such as weak soils, and reduce the number of watercourse crossings, where practicable	Section 13.0
	M153	Limit the duration of in-stream construction activities at watercourse crossings to shortest time practicable	Section 13.0
	M154	Consider the hydraulics of the watercourse in the design and construction of bridges, abutments and in-river bridge supports (where needed) and consider stability and flow disruptions	Section 13.0
	M155*	Implement industry good practice erosion and sediment control measures at watercourse crossings, as necessary	Section 13.0
	M157	Undertake terrain evaluation and mapping to identify past instabilities (e.g., landslides)	Section 13.0
	M158	River/stream crossings are to be limited in areas of high, unstable banks	Section 13.0

PERFORMANCE STANDARD THEME	MITIGATION MEASURE REFERENCE	MITIGATION MEASURE	EMP SECTION REFERENCE
	M160	Management plans will be developed for all watercourse crossings to address the sensitivities of crossings on an individual watercourse basis. Plans will consider, where relevant: • watercourse diversions requirements • disturbance limits • equipment limitations • erosion control measures • fine-scale routing at crossing sites to limit disturbance of particularly large and established riparian vegetation and complex bank habitat structure • delay of clearing of banks for temporary vehicle crossing until the need for the crossing is imminent, where practicable	Section 13.0
Performance Standard 3: Pollution Prevention and Abatement Pesticide Use and Management	M80*	Use herbicides approved by EMPNG for the control of invasive weeds where this is considered the most effective form of control	Section 15.0
Performance Standard 6: Biodiversity Conservation and Sustainable Natural Resource Management	M1*, M54*	Establish and enforce PNG LNG quarantine management program	Section 15.0
	M2*	Establish and enforce pest and weed management procedures as part of ecology, natural habitat and biodiversity plans	Section 15.0
	M4*, M64*	Limit the clearing of riparian vegetation to the width required to safely accommodate ROW, access ways and watercourse crossings. Reduce number of watercourse crossings to limit riparian soil erosion and sediment delivery to watercourses	Section 13.0
	M6*, M10*, M81, M244*	Prohibit works from exceeding the approved disturbance width and construction boundaries. Limit the movement of employees and contractors to within project-defined areas and designated traffic and transport routes or locations. Prohibit machinery from leaving the approved ROW or access ways to unnecessarily clear additional forest	Section 16.0
	M7*, M18*, M75	Reduce the period surfaces are exposed, and reinstate areas no longer required for construction or support services. Where practicable, disturbed areas will be returned to former landforms and vegetation of exposed areas will occur as soon as practicable once construction activities are completed in any particular location, taking into account the nature of subsequent activities that will be undertaken at the same sites as well as agreed end uses. Areas prone to erosion will receive particular attention	Section 13.0 and14.0

PERFORMANCE STANDARD THEME	MITIGATION MEASURE REFERENCE	MITIGATION MEASURE	EMP SECTION REFERENCE
	M8	Prohibit staff from disturbing migratory species and associated habitats, especially along perimeter fence adjacent to mudflat habitat	Section 16.0
	M9, M57, M58	Prohibit disturbance/harassment of wildlife, hunting of fauna, gathering of plants or bush foods, collection of firewood or possession of wildlife products by EMPNG workers or contractors while working, travelling in EMPNG vehicles, and residing in PNG LNG field accommodation. Implement appropriate inductions and education to encourage staff to comply with regulations	Section 16.0
	M11*, M17	Develop site-specific reinstatement plans based on land systems or equivalent and address ground preparation activities, interim and permanent soil erosion and sediment management issues, and approaches to revegetation (natural regeneration versus intervention). Use cleared vegetation where practicable for dust control and reinstatement.	Section 14.0
	M13*	Limit disturbance to sandalwood trees and other listed species where practicable.	Section 16.0
	M14*, M15, M78, M79*, M86*	Retain large trees (greater than 1 m diameter breast height) when they are situated along worksite borders, or where works can be undertaken around these trees. Exceptions to be approved by the Company. Where trees are to be felled by hand, use directional felling for trees greater than 50 cm diameter breast height so they land in natural slots between standing trees or along the axis of tracks to reduce damage to the remaining forest, where practicable. Where tree removal is necessary for linear construction (roadways, ROW), limit damage to surrounding habitats by felling trees away from existing stands where practicable taking into account the value of the areas into which the trees are being felled, and safety factors. Limit the scraping of standing tree trunks by machinery as far as practicable	Section 16.0
	M22	At new or improved road crossings, maintain connectivity of wet season flow in watercourses, avoiding the creation of high-velocity 'chutes' or step-down cascades in order to enable fish migration	Section 13.0
	M41*, M220	Where practicable, utilise shielding / treatments for the reduction of light spill into the marine environment to reduce visibility of the site from Ihidi Island where turtles may be nesting. Reduce lighting on jetty when not loading while meeting navigation and security guidelines	Section 6.0
	M53*	Prohibit establishment of gardens with introduced plants (unless approved by EMPNG for landscaping purposes) and introduction of exotic plants or animals by PNG LNG workers and contractors	Section 15.0
	M56*, M59*, M111	Implement speed limits on EMPNG-controlled roads and access ways to reduce vehicle collisions with wildlife. Patrol open trench to rescue and record fauna that fall into the open pipeline trench	Section 16.0
	M68*, M69*	Reduce the number of quarries developed by using previously worked (old) quarries, where practicable, and using limestone generated by construction activities for road base material. Source quarry and aggregate material only from quarries approved by EMPNG.	Section 11.0

PERFORMANCE STANDARD THEME	MITIGATION MEASURE REFERENCE	MITIGATION MEASURE	EMP SECTION REFERENCE
	M12*, M74*, M119*, M121, M122*, M123*, M124*	Where practicable, utilize land-clearing techniques that preserve the rootstock of removed vegetation in the ground. Cleared vegetation and topsoil will be conserved and stockpiled in a manner that facilitates, respreading or salvaging, e.g. place on one side of cleared areas. Topsoil, mulch and discarded vegetation debris (including natural seed stock) will be spread on reclaimed or rehabilitated disturbed land surfaces to facilitate natural revegetation. Where appropriate, undertake active works to re-establish vegetation in areas that may be slow or difficult to regenerate naturally, difficult to stabilise or prone to erosion	Section 14.0
	M113*	Require that in-country timber is acquired from legal EMPNG approved sources	Section 11.0
	M117*	Maintain vehicle washdown facilities, contain the material washed from machinery/equipment for appropriate disposal, contain and treat washdown water as necessary	Section 15.0
	M118*	Maintain procedures to control invasive species and plant pathogens. Weed and exotic pest control management procedures that identify foreign and invasive weed and exotic pest threats will be implemented in the invasive species and plant pathogens monitoring procedure and appropriate control measures will be taken	Section 15.0
	M139*	Stabilise disturbed batter slopes and cleared banks to facilitation reinstatement	Section 14.0
	M222*	A PNG LNG quarantine management plan will follow International Maritime Organization requirements and industry good practice with respect to ballast water discharge and hull cleaning to prevent the introduction of invasive species	Section 15.0
	M223	Maintain existing alongshore sediment transport patterns in the vicinity of the Vaihua River mouth	Section 14.0 Section 18.0

PERFORMANCE STANDARD THEME	MITIGATION MEASURE REFERENCE	MITIGATION MEASURE	EMP SECTION REFERENCE
Performance Standard 8: Cultural Heritage	M225*	Conduct Cultural Heritage Survey by systematically recording and mapping cultural heritage sites in all areas designated for disturbance during construction, including any areas that were characterised but not surveyed for the PNG LNG EIS	Section 17.0
	M226	Consult and liaise with the PNG National Museum and Art Gallery as required for surveys and check all surveys are supervised by appropriately-qualified archaeologists and cultural heritage specialists. Liaise with the National Cultural Commission through the PNG National Museum and Art Gallery as appropriate	Section 17.0
	M227*, M230, M241*	Develop and implement a cultural heritage management plan in consultation with the Museum and Art Gallery, archaeologists and cultural heritage specialists	Section 17.0
	M229	Conduct further research of appropriate archives as part of site pre-construction surveys, where relevant and required	Section 17.0
	M232*, M238*	Engage appropriately-qualified archaeologists and cultural heritage specialists to coordinate and direct salvage of known sites prior to disturbance, in consultation with the PNG National Museum and Art Gallery, as required	Section 17.0
	M233*	For significant sites encountered during construction, consult with PNG National Museum and Art Gallery as described in chance finds protocol	Section 17.0
	M239*	Periodically monitor cultural sites within the vicinity of pipelines and facilities to ensure EMPNG personnel are not disturbing these sites	Section 17.0
	M245*, M248*, M253*	Delineate the boundaries and establish access control zones around the ancient village site complex known as Aemakara and cultural heritage site Konekaru, and avoid disturbing these sites	Section 17.0
*Note: The language of some measures has been revised since the PNG LNG EIS to better reflect actual circumstances and provide greater clarity.			

APPENDIX 2: SUMMARY OF EMISSIONS AND DISCHARGES

SUMMARY OF EMISSIONS TO AIR					
SOURCE NOTE 1	**NATURE**	**POLLUTANTS** NOTE 2	**GUIDELINE**		**MONITORING**
Compressor gas turbines	Continuous	Oxides of nitrogen	25 ppm NOTE 3		NOTE 4
Main power generators			42 ppm NOTE 3		
Wet flare stack (purge and pilot gas)	Continuous		N/A		N/A
Dry flare stack (purge and pilot gas)			N/A		N/A
Tankage flare (purge and pilot gas)			N/A		N/A
Essential services generators	Intermittent	Oxides of nitrogen, carbon monoxide, sulphur dioxide	N/A		N/A
Diesel firewater pump					
Diesel sea firewater pump					
Process waste incinerator		Waste dependent NOTE 5	PM	70 mg/m^3 NOTE 6	NOTE 4
			Carbon monoxide	157 ppm	
			Oxides of nitrogen	388 ppm	
			Oxides of sulphur	20 ppm	
			Hydrogen chloride	62 ppm	
			Cadmium	0.004 mg/m^3	
			Lead	0.04 mg/m^3	
			Mercury	0.47 mg/m^3	
			Dioxin/furan	0.41 ng/m^3	
			Opacity	10 percent	
General waste incinerator	Intermittent	Waste dependent NOTE 5	PM	270 mg/m^3 NOTE 7	
			Carbon monoxide	13 ppm	
			Oxides of nitrogen	170 ppm	
			Oxides of sulphur	1.2ppm	

SUMMARY OF EMISSIONS TO AIR					
SOURCE NOTE 1	**NATURE**	**POLLUTANTS** NOTE 2	**GUIDELINE**		**MONITORING**
			Hydrogen chloride	200 ppm	
			Cadmium	0.67 mg/m^3	
			Lead	2 mg/m^3	
			Mercury	0.0035 mg/m^3	
			Dioxin/furan	31 ng/dscm	
			Fugitive ash	Visible emissions for no more than 5 percent of the hourly observation period.	

SUMMARY OF DISCHARGES TO WATER						
DISCHARGE TYPE	**SOURCE**	**NATURE**	**POLLUTANTS AND GUIDELINE VALUES** NOTE 8			**MONITORING**
				WATER QUALITY CRITERIA (FRESHWATER)	**WATER QUALITY CRITERIA (SEAWATER)**	
Stormwater	LNG Plant	Intermittent	pH	6.5 – 9 (pH units)	Within natural pH range	Periodic in-situ sampling
			Turbidity	No alteration greater than 25 NTU or no change of more than 10 percent above background levels at any particular time (whichever is greater)	No alteration greater than 25 NTU or no change of more than 10 percent above background levels at any particular time (whichever is greater)	
			Dissolved oxygen	Not less than 6 mg/l or no change of more than 10 percent below background levels at any particular time (whichever is smaller)	Not less than 5 mg/l or no change of more than 10 percent below background levels at any particular time (whichever is smaller)	
			Total Suspended Solids	50 mg/l or no change of more than 10 percent above background levels at any particular time (whichever is greater)	50 mg/l or no change of more than 10 percent above background levels at any particular time (whichever is greater))	
			Oil and grease	No visible film	No visible film	
Sanitary wastewater	LNG Plant ➢ Sanitary wastewater treatment plants ➢ Sanitary Sludge Drying Bed ➢ Landfill leachate	Intermittent	pH	6.5 – 9 (pH units)	Within natural pH range	Periodic in-situ sampling
			Biological oxygen demand	25 mg/l	25 mg/l	
			Chemical oxygen demand	125 mg/l	125 mg/l	
			Ammonia-nitrogen	Dependent on pH and temperature (see Table 9-3)	0.5 mg/l**	
			Total Suspended Solids	50 mg/l	50 mg/l	
			Oil and grease	10 mg/l	10 mg/l	

SUMMARY OF DISCHARGES TO WATER						
DISCHARGE TYPE	**SOURCE**	**NATURE**	**POLLUTANTS AND GUIDELINE VALUES** NOTE 8			**MONITORING**
				WATER QUALITY CRITERIA (FRESHWATER)	**WATER QUALITY CRITERIA (SEAWATER)**	
			Faecal contamination risk	Faecal coliform: Not to exceed 200 colonies per 100 ml **OR** Not to exceed medium faecal contamination risk (refer to Table 9-4 and Table 9-5). **OR** Residual chlorine: as close as possible to 1 mg/l	Faecal coliform: Not to exceed 200 colonies per 100 ml **OR** Not to exceed medium faecal contamination risk (refer to Table 9-4 and Table 9-5). **OR** Residual chlorine: as close as possible to 1 mg/l	
Process	LNG Plant: ➢ Oily wastewater treatment system ➢ Stormwater (process areas) ➢ Desalination reject brine ➢ Retention pond	Intermittent	pH	6.5 – 9 (pH units)	Within natural pH range	Periodic in-situ sampling
			Temperature	No alteration greater than 2 degrees Celsius	No alteration greater than 2 degrees Celsius	
			Total Suspended Solids	50 mg/l	50 mg/l	
			Dissolved oxygen	Not less than 6 mg/l or no change of more than 10 percent below background levels at any particular time (whichever is smaller)	Not less than 5 mg/l or no change of more than 10 percent below background levels at any particular time (whichever is smaller)	
			Chemical oxygen demand	125 mg/l	125 mg/l	
			Biological oxygen demand	25 mg/l	25 mg/l	
			Sulphate as $SO4^{2-}$	400 mg/l	---	
			Sulphide as HS-	0.002 mg/l	0.002 mg/l	
			Ammonia-nitrogen	Dependent on pH and temperature (see Table 9-3)	0.5 mg/l**	

SUMMARY OF DISCHARGES TO WATER						
DISCHARGE TYPE	**SOURCE**	**NATURE**	**POLLUTANTS AND GUIDELINE VALUES** NOTE 8			**MONITORING**
				WATER QUALITY CRITERIA (FRESHWATER)	**WATER QUALITY CRITERIA (SEAWATER)**	
			Nitrate	45 mg/l	45 mg/l	
			Potassium	5 mg/l	600 mg/l	
			Barium	1 mg/l	1 mg/l	
			Boron NOTE 9	1 mg/l	10 mg/l	
			Cadmium	0.01 mg/l	0.001 mg/l	
			Chromium (as hexavalent)	0.05 mg/l	0.01 mg/l	
			Cobalt	Limit of detection	Limit of detection	
			Copper	1 mg/l	0.03 mg/l	
			Iron	1 mg/l	1 mg/l	
			Lead	0.005 mg/l	0.004 mg/l	
			Manganese	0.5 mg/l	2 mg/l	
			Mercury	0.0002 mg/l	0.0002 mg/l	
			Nickel	1 mg/l	1 mg/l	
			Selenium	0.01 mg/l	0.01 mg/l	
			Silver	0.05 mg/l	0.05 mg/l	
			Tin	0.5 mg/l	0.5 mg/l	
			Zinc	5 mg/l	5 mg/l	
			Oil and grease	10 mg/l	10 mg/l	
			Phenol^	0.085 mg/l	0.270 mg/l	
			2-chlorophenol^	0.340 mg/l	-	
			4-chlorophenol^	0.160 mg/l	-	

SUMMARY OF DISCHARGES TO WATER						
DISCHARGE TYPE	**SOURCE**	**NATURE**	**POLLUTANTS AND GUIDELINE VALUES** NOTE 8			**MONITORING**
				WATER QUALITY CRITERIA (FRESHWATER)	**WATER QUALITY CRITERIA (SEAWATER)**	
			2,4-dichlorophenol^	0.120 mg/l	-	
			2,4,6-trichlorophenol^	0.003 mg/l	-	
			2,3,4,6-tetrachlorophenol^	0.010 mg/l	-	
			Pentachlorophenol^	0.0036 mg/l	0.011 mg/l	
			Methyl diethanolamine (MDEA)**	-	1.50 mg/l	
			Diethanolamine (DEA)**	-	0.36 mg/l	
			Ethanolamine (EA)**	-	0.38 mg/l	
			Piperazine**	-	3.70 mg/l	
			Faecal contamination risk€	Faecal coliform: Not to exceed 200 colonies per 100 ml **OR** Not to exceed medium faecal contamination risk (refer to Table 9-4 and Table 9-5). **OR** Residual chlorine: as close as possible to 1 mg/l	Faecal coliform: Not to exceed 200 colonies per 100 ml **OR** Not to exceed medium faecal contamination risk (refer to Table 9-4and Table 9-5). **OR** Residual chlorine: as close as possible to 1 mg/l	

SUMMARY OF DISCHARGES TO WATER						
DISCHARGE TYPE	**SOURCE**	**NATURE**	**POLLUTANTS AND GUIDELINE VALUES** NOTE 8			**MONITORING**
				WATER QUALITY CRITERIA (FRESHWATER)	**WATER QUALITY CRITERIA (SEAWATER)**	

Note 1: This table does not include emission sources associated with vents or pressure relief devices such as pressure control valves or pressure vacuum safety valves at LNGP, for details refer to Section 6.0.

Note 2: Includes only the key pollutants of relevance.

Note 3: Based on Environmental, Health, and Safety General Guidelines (IFC, 2007), Table 1.1.2 - Small Combustion Facilities Emissions Guidelines.

Note 4: Stack testing will be undertaken twice yearly for the first two years of operation. Thereafter for each emission source, monitoring frequency and scope can be reduced such that:

- Stack testing is conducted every three years if monitoring results meet the required criteria; or annually if not until the required criteria is met; and
- A representative selection of air emission sources is included in each stack testing program.

Note 5: Incinerator emissions will depend upon the composition of the waste incinerated during each burn cycle.

Note 6: Process waste incinerator parameters are based on Title 40 – Protection of Environment, Part 60 – Standard of Performance for New Stationary Sources [40 CFR 60] (United States Environmental Protection Agency, 2008), Subpart CCCC (Standards of Performance for Commercial and Industrial Solid Waste Incineration Units), including threshold for applicability relating to throughput, as referenced in Environmental, Health and Safety Guidelines for Waste Management Facilities (IFC, 2007).

Note 7: General water incinerator parameters are based on Title 40 – Protection of Environment, Part 60 – Standard of Performance for New Stationary Sources [40 CFR 60] (United States Environmental Protection Agency, 2008), Subpart CCCC (Standards of Performance for Commercial and Industrial Solid Waste Incineration Units), Table 8- Emission Limitations for Small, Remote Incinerators That Commenced Construction After June 4, 2010, Or That Commenced Reconstruction or Modification After August 7, 2013

Note 8: Annex 2 of the Environment Permit, based on *Environment (Water Quality Criteria) Regulation 2002*, Water Quality Criteria for Aquatic Life Protection.

Note 9: Value for boron agreed with CEPA due to high background levels in Caution Bay.

**Site-specific criteria for MDEA, DEA, EA, piperazine and ammonia-nitrogen approved by CEPA in their letter dated 20 April 2017 (reference: 2017_12067.1).

^Source: Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, 2000). Trigger values adopted for a slightly to moderately disturbed aquatic ecosystem with a high conservation value (99 percent species level protection).

€Criteria for faecal contamination risk only applies at the retention pond when effluent from the sanitary wastewater treatment plant(s) are discharged into the LNG Plant retention pond