Esso Highlands Limited

Papua New Guinea LNG Project

Environmental Management Plan: Upstream Facilities, Infrastructure and Pipelines

CONTENTS

TABLES

FIGURES

APPENDICES

ACRONYMS

ACRONYM	DESCRIPTION
µg/m^3	micrograms per cubic metre
AGI	Above Ground Installation
AWPAR	Angore Wellpad Access Road
BTEX	Benzene, toluene, ethylbenzene, and xylene
CP	Cathodic Protection
CPF	Central Processing Facility
CV	Check Valve
dBA	A-weighted decibels
DEC	Papua New Guinean Department of Environment and Conservation
DN	Nominal Diameter
E&R	Environmental and Regulatory
EHL	Esso Highlands Limited
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
GPF	Gobe Production Facility
HGCP	Hides Gas Conditioning Plant
HVWF	Hides Vehicle Wash Facility
HWMF	Hides Waste Management Facility
HWPAR	Hides Wellpad Access Road
IESC	Independent Environmental and Social Consultant
IFC	International Finance Corporation
IUCN	International Union for Conservation of Nature
KP	Kilometre Point
LNG	Liquefied Natural Gas
MEG	monoethylene glycol
MEGVG	monoethylene glycol (MEG) Vent Gas
mg/m^3	milligrams per standard cubic metre
MLV	Main Line Valve
ng/m^3	nanograms per standard cubic metre
OIMS	Operations Integrity Management System
OSL	Oil Search Limited
PNG	Papua New Guinea
PM	Particulate Matter
ppm	parts per million
PWRW	Produced Water Reinjection Well

ACRONYM	DESCRIPTION
RoW	Right of Way
SHE	Safety, Health and Environment
WHRU	Waste Heat Recovery Unit
WWTP	Wastewater Treatment Plant

1.0 INTRODUCTION

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

1.1 Scope

This Environmental Management Plan (EMP) is applicable to the following facilities and infrastructure, collectively referred to as Upstream Facilities, Infrastructure and Pipelines:

- Hides Gas Field Wellpads (Wellpads B, C, D, E 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 (HGCP)
- Hides Waste Management Facility (HWMF)
- Hides Vehicle Wash Facility (HVWF)
- 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 (AGIs)
- PNG LNG Gas Pipeline (onshore/offshore)
- PNG LNG Gas Pipeline AGIs
- Pipeline and AGI Access Tracks

The location of the Upstream Facilities, Infrastructure and Pipelines is shown in Figure 1-1 and Figure 1-2.

This EMP is not applicable to the LNG Plant and Marine Facilities, which is addressed in the Environmental Management Plan: LNG Plant and Marine Facilities.

This EMP is applicable to normal operating conditions, start-up and shut-down activities, and reasonably foreseeable abnormal operating conditions and emergency situations.

This EMP is applicable to the activities of Esso Highlands Limited (EHL) including its contractors and subcontractors. Where deemed necessary by EHL, 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 EHL documents developed on the basis of standard industry methods, where applicable.

1.2 Objectives

This EMP describes the measures in place to manage environmental aspects pertaining to the Upstream Facilities, Infrastructure and Pipelines and implement applicable legal and other requirements.

Specific environmental management objectives are outlined in Section 4.0.

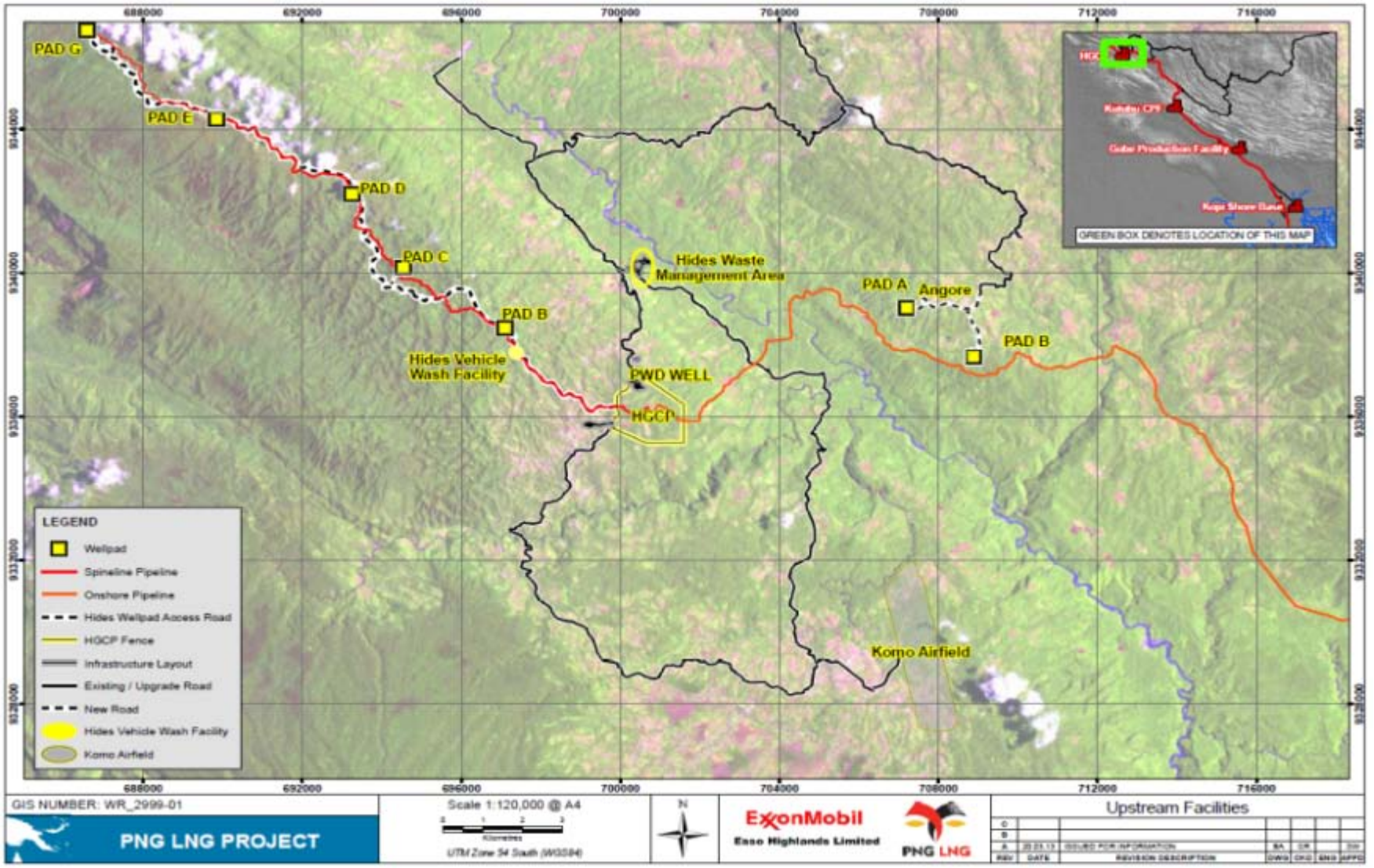

Figure 1-1: Upstream Facilities and Infrastructure location map

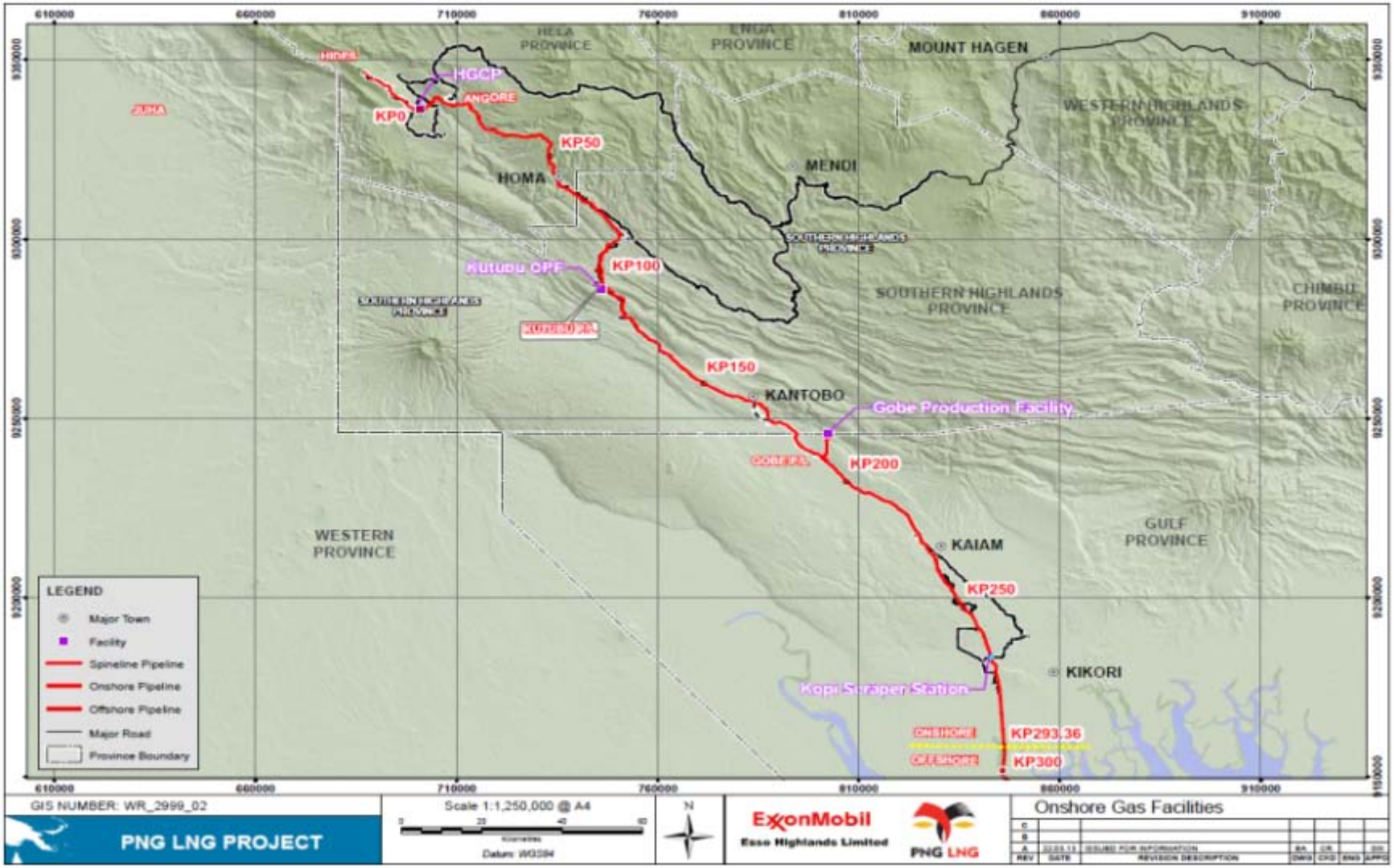

Figure 1-2: Pipelines and Above Ground Installations location map

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 relevant to this EMP are as follows:

- *Environment Act 2000*
- *Environmental (Prescribed Activities) Regulation 2002*
- *Environmental (Procedures) Regulation 2002*
- *Environmental (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*
- *Inflammable Liquid Act 1953* and Regulations
- *Public Health Act 1973*
- *Public Health (Sanitation and General) Regulation 1973*
- *Public Health (Sewerage) Regulation 1973*
- *Water Supply and Sewerage Act 1996*
- *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 the Project pursuant to the *Environment (Prescribed Activities) Regulation 2002*. The Environment Permit was issued by the Papua New Guinean Department of Environment and Conservation (DEC) on 9 September 2009. Amendments to the Environment Permit were issued on 29 October 2009 and 22 October 2012.

This EMP, together with the Environmental Management Plan: LNG Plant and Marine Facilities, 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.

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).

The OIMS Framework 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 and specific OIMS requirements are discussed where relevant, throughout this EMP.

2.4 Lender Group requirements

Debt financing was secured for the Project 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 (IFC) Performance Standards and associated Guidance Notes and Guidelines.

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

- *Performance Standard 1: Social and Environmental Assessment and Management Systems (IFC, 2006)*
- *Performance Standard 3: Pollution Prevention and Abatement (IFC, 2006)*
- *Performance Standard 4: Community Health, Safety and Security (IFC, 2006)*
- *Performance Standard 6: Biodiversity Conservation and Sustainable Natural Resource Management (IFC, 2006)*
- *Performance Standard 8: Cultural Heritage (IFC, 2006)*
- *Guidance Note 1: Social and Environmental Assessment and Management Systems (IFC, 2007)*
- *Guidance Note 3: Pollution Prevention and Abatement (IFC, 2007)*
- *Guidance Note 4: Community Health, Safety and Security (IFC, 2007)*
- *Guidance Note 6: Biodiversity Conservation and Sustainable Natural Resource Management (IFC, 2007)*
- *Guidance Note 8: Cultural Heritage (IFC, 2007)*
- *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 IFC Performance Standards, Guidance Notes and Guidelines are discussed where relevant in this EMP.

3.0 ORGANISATION

OIMS System 1-1 Management Leadership 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 EHL's organisation as relevant to environmental management during production is provided in this section.

3.1 OIMS Management Committee

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

As such, EHL will charter an OIMS Management 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 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

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

An outline of EHL's SHE organisation 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 organisation, other EHL production and maintenance personnel have defined roles and responsibilities in respect of this EMP. Roles and responsibilities of key personnel are described in Section 22.0. Competency and training is discussed in Section 23.0.

The organisation shown below includes only EHL personnel. EHL will retain third party consultants and other specialist organisations and individuals as necessary to support implementation of this EMP.

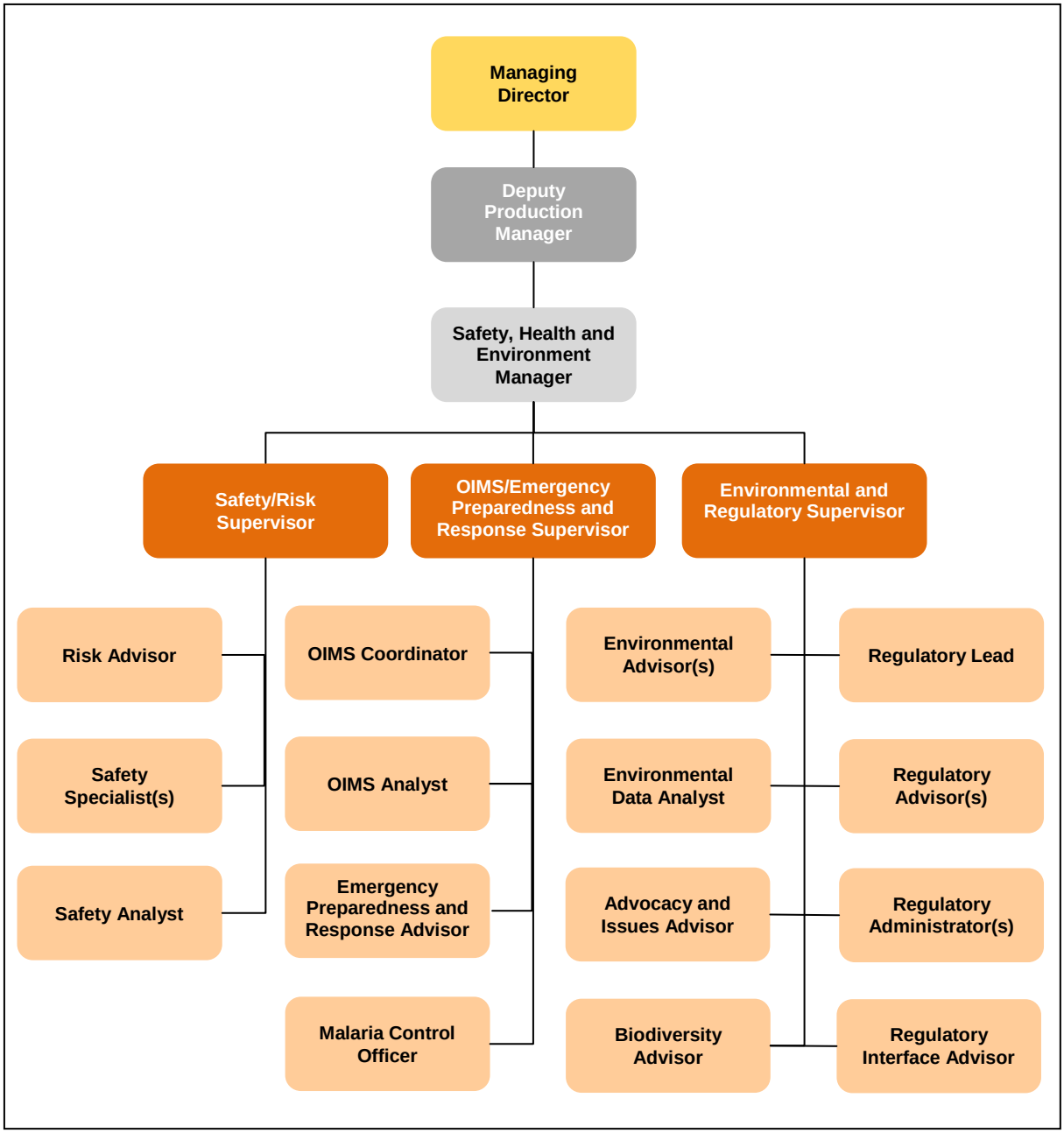

Figure 3-1: Safety, Health and Environment organisation

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 process of identification and evaluation of environmental aspects relevant to production is summarised below, as context to the environmental management and mitigation measures set out in this EMP.

4.1 Environmental impact assessment

Environmental aspects and impacts associated with production were initially identified and evaluated as part of the impact assessment conducted for the Environmental Impact Statement (EIS) for the Project. The EIS was finalised and submitted to the DEC 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 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 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 Upstream Facilities, Infrastructure and Pipelines are within the scope of this EMP and are shown in Appendix 1.

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

4.2 Environmental Aspects Assessment

OIMS System 6-5 Environmental Management requires the identification of environmental aspects. An environmental aspect is an activity, product or service that interacts with the environment and may have beneficial, adverse, and/or neutral effects. Environmental aspects are to be 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, EHL undertook an Environmental Aspects Assessment for production operations. 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 Upstream Facilities, Infrastructure and Pipelines, 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.

4.3 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 EHL and other personnel).

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

IFC PERFORMANCE STANDARD THEME	ENVIRONMENTAL ASPECT CATEGORY	ENVIRONMENTAL ASPECT OVERVIEW	RISK SCENARIO OVERVIEW	EMP SECTION REFERENCE
Performance Standard 3: Pollution Prevention and Abatement (IFC, 2006) Pollution Prevention, Resource Conservation and Energy Efficiency	Emissions and releases to air	HGCP compressor gas turbine emissions.	Risk of health and ecological impacts associated with release of pollutants to air.	Section 6.0
		HGCP main power generator emissions.		
		HGCP monoethylene glycol vent gas incinerator emissions.		
		HGCP incinerator emissions.		
		HGCP high pressure flare emissions.		
		HGCP pressure control valve emissions.		
		HGCP pressure safety valve emissions.		
		HGCP atmospheric vent emissions.		
		HWMF incinerator emissions.		
		Pipeline blowdown 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
		HGCP noise.	Risk of health and ecological impacts associated with exposure to noise.	Section 8.0
		HWMF noise.		
		Komo noise.		
		Pipeline AGI noise.		
	Discharges and releases to water	HGCP stormwater discharges.	Risk of health and ecological impacts associated with the release of pollutants to surface water and	Section 9.0
		HGCP open drain system discharges.		

IFC PERFORMANCE STANDARD THEME	ENVIRONMENTAL ASPECT CATEGORY	ENVIRONMENTAL ASPECT OVERVIEW	RISK SCENARIO OVERVIEW	EMP SECTION REFERENCE
		HGCP retention pond discharges.	groundwater.	
		HGCP domestic wastewater discharges.		
		HWMF stormwater discharges.		
		HWMF process building discharges.		
		HWMF domestic wastewater discharges.		
		HWMF leachate system discharges.		
		Komo stormwater discharges.		
		Komo open drain discharges.		
		Komo domestic wastewater discharges.		
		Pipeline AGI stormwater discharges.		
		Wash water discharge.		
Performance Standard 3: Pollution Prevention and Abatement (IFC, 2006) Waste	Waste	Waste avoidance and minimisation.	Risk of health and ecological impacts associated with release of pollutants in waste.	Section 12.0
		Waste collection.		
		Waste storage and transfer.		
		Waste reuse, recycling and recovery.		
		Waste treatment and disposal.		
		Waste tracking and documentation.		
Performance Standard 3: Pollution Prevention and Abatement (IFC, 2006) 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.		

IFC PERFORMANCE STANDARD THEME	ENVIRONMENTAL ASPECT CATEGORY	ENVIRONMENTAL ASPECT OVERVIEW	RISK SCENARIO OVERVIEW	EMP SECTION REFERENCE
Performance Standard 3: Pollution Prevention and Abatement (IFC, 2006) 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 (IFC, 2006) Greenhouse Gas Emissions	Emission and releases to air (greenhouse gases)	Emissions of greenhouse gases from HGCP.	Contribution to climate-related effects associated with the release of greenhouse gases.	Section 6.0
		Emissions of greenhouse gases from HWMF.		
		Emissions of greenhouse gases from Komo.		
Performance Standard 3: Pollution Prevention and Abatement (IFC, 2006) 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 6: Biodiversity Conservation and Sustainable Natural Resource Management (IFC, 2006)	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 and pests.	Risk of impacts to biodiversity values and subsistence and commercial agriculture associated with the introduction and/or spread of priority invasive species and pests.	Section 15.0
		Plant pathogens.	Risk of impacts to biodiversity values associated with the spread of plant pathogens.	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

IFC PERFORMANCE STANDARD THEME	ENVIRONMENTAL ASPECT CATEGORY	ENVIRONMENTAL ASPECT OVERVIEW	RISK SCENARIO OVERVIEW	EMP SECTION REFERENCE
		Control of access to Project roads and infrastructure.	Risk of impacts to biodiversity values associated with the use of Project roads and infrastructure by third party vehicles.	Section 17.0
	Water usage	Abstraction of surface water and groundwater.	Risk of impacts to community use or ecological flows associated with the abstraction of water.	Section 11.0
	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 (IFC, 2006)	Cultural heritage	Management of known and unknown archaeological and oral tradition sites.	Risk of impacts to cultural heritage.	Section 18.0

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 EHL facilities and licensed third party facilities only
Erosion and sediment control	• Control significant erosion and prevent significant sedimentation of surface waters
Regeneration	• Promote regeneration of vegetation in areas disturbed during construction and not required for production • Achieve established benchmarks for regeneration areas
Invasive species, pests and plant pathogens	• Prevent priority invasive species and plant pathogens from entering or establishing in the Project area • Contain priority invasive species and plant pathogens already established in the Project area
Ecology	• Avoid impacts to specific features of ecological importance
Enhanced access	• Control vehicle access to Project roads and infrastructure to prevent potentially damaging third party activities
Cultural heritage	• Avoid impacts to 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 Upstream Facilities, Infrastructure and Pipelines is provided in this section.

5.1 Hides Wellpads and Hides Wellpad Access Road

There are eight producing wells at Hides located across a total of four wellpads (two producing wells at Wellpads B, C, D and G). There are no producing wells at Wellpad E.

A flowline connects each wellpad with the Hides Spineline.

Facilities at each producing wellpad vary but typically include a wellhead tree; production piping and valves; monoethylene glycol (MEG) injection piping and valves; corrosion inhibitor storage tank and injection pumps; hydraulic power system; closed and open drain systems; vent knockout drums and pots; local equipment room including controls and electrical equipment.

MEG is used for suppression of hydrates (crystals which may form in the presence of water under certain conditions and may cause line plugging) and is delivered to each producing wellpad via a pipeline from the HGCP. Corrosion inhibitor is injected via individual pumps located at each wellpad.

The Hides Wellpad Access Road (HWPAR) is approximately 22 kilometres long, extending north-west from the HGCP to Hides Wellpad G. A diagram of the Hides Wellpads and HWPAR is shown in Figure 5-1.

5.2 Angore Wellpads and Angore Wellpad Access Road

There are two producing wells at Angore located across two wellpads (Angore Wellpad A and Angore Wellpad B). Facilities at the Angore Wellpads are the same as described above for the Hides Wellpads. The Angore Wellpads are accessed via the Angore Wellpad Access Road (AWPAR), which is approximately 18 kilometres long.

5.3 Produced Water Reinjection Well

An injection well is required for the disposal of produced water from the HGCP. The Produced Water Reinjection Well (PWRW) is located within the perimeter of the HGCP. It has a capacity of 40 cubic metres per hour and provides the required injection pressure of approximately 44,000 kilopascals.

5.4 Hides Gas Conditioning Plant

The HGCP is located in the Hela Province at the south-east base of the Hides Ridge near the village of Laite. The HGCP includes a processing facility and an industrial park within shared security and perimeter fences.

The processing facility processes multi-phase wellstream fluids from the Hides Gas Field and is designed to stabilise and condition the wellstream fluids into two separate phases, a condensate phase and dry gas phase.

Process systems currently comprise inlet facilities including slug handling; gas and liquid inlet separation; dewpoint conditioning; compression; produced water injection; condensate stabilisation and condensate transfer system. A number of utilities support the HGCP including fuel gas system; MEG storage, distribution, and regeneration; chemical injection systems; portable methanol skid; hot oil system; main power generation; essential power generation; diesel storage and distribution system; instrument and utility air system; high pressure and low pressure flare systems; closed and open drain systems; MEG vent gas incineration; slop oil storage and transfer; firewater system; utility water storage and distribution; potable water system and nitrogen reticulation system.

The industrial park provides the facilities necessary to support production and maintenance of the HGCP, including a warehouse; chemical and hazardous materials storage shelter; outdoor storage yard; maintenance workshop; vehicle workshop; laboratory; diesel fuel storage and distribution station; waste management depot; incinerator, and other associated infrastructure. A diagram of the HGCP is shown in Figure 5-2.

5.5 Hides Waste Management Facility

The HWMF receives and treats waste generated throughout the Hides and Komo areas. The HWMF currently comprises a weighbridge; process building; drum crusher and cleaner; tyre debeader; shredder; sewage sludge dewatering system; incinerator; ash stabilisation system; landfill and leachate treatment system. A diagram of the HWMF is shown in Figure 5-3.

5.6 Hides Vehicle Wash Facility

A permanent vehicle wash facility, the HVWF operates on the lower section of the HWPAR at Kilometre Point (KP) 3.5 to prevent the spread of invasive species (weeds, plant pathogens and pests) onto the Hides Ridge. A diagram of the HVWF is shown in Figure 5-4.

5.7 Komo Airfield

Komo Airfield, located 20 kilometres south-east of Hides, was developed to support construction and production of the HGCP. The Airfield facility is privately owned and operated by EHL. It includes a: 3,200-metre sealed runway; taxiway and aprons; terminal building; hangar; freight storage area; powerhouse; fuel depot; guard house; along with fire fighting and rescue services; boundary and security fencing; and navigation aids.

Komo Airfield services operations of DHC8-300 (Dash-8) fixed wing aircraft and Bell 412 or 212 rotary wing aircraft (helicopters). It is primarily used for transportation of personnel, including limited international flights. A diagram of the Komo Airfield is shown in Figure 5-5.

5.8 Hides Gathering System and Hides Spineline

The Hides Gathering System consists of flowlines, a spineline, and a MEG Pipeline.

A series of flowlines connect the Hides Wellpads B, C, D and G to the Hides Spineline. The flowlines transport wellstream fluids from each well to manually operated isolation valves on the Hides Spineline, which transports the combined well stream fluids to the HGCP. The MEG Pipeline originates from the HGCP and transports MEG to each of the Hides Wellpads B, C, D and G. The Hides Spineline and MEG Pipeline are located directly in parallel to each other within the same Right of Way (RoW), over a length of approximately 25 kilometres.

The Hides Spineline is pigged on a regular basis via a pig launcher at Hides Wellpad G and pig receiver at the HGCP.

5.9 Angore Gathering System and Angore Spineline

The Angore Gathering System comprises a spineline from the Angore B Wellpad to the HGCP and a MEG Pipeline.

The Angore Spineline transports combined well stream fluids from Angore Wellpad A and Angore Wellpad B to the HGCP. The MEG Pipeline originates from the HGCP and transports MEG to each of the Angore Wellpads A and B. The Angore Spineline and MEG Pipeline are located directly in parallel to each other within the same RoW over a length of approximately 18 kilometres.

The Angore Spineline is pigged on a regular basis via a pig launcher located at each of the Angore Wellpads A and B and a pig receiver at the HGCP.

5.10 HGCP-Kutubu Condensate Pipeline

A Nominal Diameter (DN) 200 (8-inch) condensate pipeline transports the conditioned liquid stream condensate from the HGCP to the Kutubu Central Processing Facility (CPF).

The condensate pipeline is located within the same RoW as the gas pipeline between HGCP and the Kutubu CPF. The condensate pipeline ties in with the Kutubu Main Line Valve (MLV).

The condensate pipeline is pigged on a quarterly basis via a pig launcher located at the HGCP and a pig receiver at the Kutubu CPF Metering Station.

The route of the condensate pipeline is shown in Figure 1-2.

5.11 HGCP-Kutubu Condensate Pipeline Above Ground Installations

Several AGIs serve the condensate pipeline:

- 4 MLVs
- 2 Check Valves (CVs)
- Kutubu CPF Metering Station

A summary of services located at the AGIs is shown in Table 5-1.

Table 5-1: Services at HGCP-Kutubu Condensate Pipeline Above Ground Installations

SERVICE	FACILITY						
	MLV 1	MLV 2	MLV 3	MLV 4	CV 1	CV 2	KUTUBU CPF METERING STATION
Generator	✓	✓	✓	✓			
Pig receiver							✓
Pig launcher							Future
Blowdown vent				✓			
Cathodic protection	✓		✓				
Condensate drain tank							✓
Helipad	✓	✓	✓	✓	✓	✓	
Emergency accommodation	✓	✓	✓	✓			

The MLVs enable isolation of five discrete sections of the condensate pipeline in case of repair or emergency. The MLVs are spaced to reduce the volume of release, should it occur.

The MLVs can be operated locally or remotely controlled from the HGCP, and include an actuated shutdown valve with a bypass containing isolation valves. The buildings house an equipment shelter, emergency accommodation and a diesel generator, and a helipad is provided for access by air.

A diagram of MLV1 is shown in Figure 5-6.

The CVs enable further isolation of the condensate pipeline in case of repair or emergency. One CV is located immediately upstream of the Tagari Fault Crossing to limit exposure to the Tagari River and the other is located approximately 10 kilometres downstream of MLV4 to the north of Lake Kutubu to limit exposure of the Lake Kutubu catchment. Environmental aspects associated with the CVs are negligible and they are not discussed further in this EMP.

The Kutubu CPF Metering Station houses two metering skids, one of which measures the volume of condensate delivered to the Kutubu CPF operated by Oil Search Limited (OSL) and the other which measures the volume of associated gas being delivered from the Kutubu CPF to the gas pipeline. A condensate drain tank receives any condensate loss from the pig receiver. Power and water are provided from the adjacent OSL facilities.

5.12 PNG LNG Gas Pipeline onshore

The PNG LNG Gas Pipeline (the gas pipeline) delivers conditioned dry gas from HGCP to the Omati River Landfall. It is a DN 800 (32-inch) carbon steel pipeline from the HGCP to the Kopi Scraper Station and a DN 850 (34-inch) line from there to the Main Interface Joint, close to the Omati River Landfall. The total length of the onshore section is approximately 290 kilometres. The gas pipeline is located within the same RoW as the condensate pipeline between HGCP and the Kutubu MLV. From there, the gas pipeline generally runs in parallel to the existing oil export line operated by OSL, until a deviation south of the Kaiam River.

The gas pipeline is pigged regularly via pig launchers at the HGCP and Kopi Scraper Station and a pig receiver at the LNG Plant.

The route of the onshore section of the gas pipeline is shown in Figure 1-2.

5.13 PNG LNG Gas Pipeline offshore

The offshore section of the gas pipeline is a DN 900 (36-inch) diameter carbon steel pipeline with concrete coating. It delivers gas between the Omati River Landfall and the LNG Plant located near Port Moresby. The offshore section is located initially at the bed of the Omati River for approximately 24 kilometres and then skirts the continental shelf of the Gulf of Papua to the landfall at Caution Bay. The total length of the offshore section is approximately 383 kilometres.

Environmental aspects associated with the offshore section are negligible and it is not discussed further in this EMP.

The route of the offshore section of the gas pipeline is shown in Figure 1-2.

5.14 PNG LNG Gas Pipeline Above Ground Installations

Several AGIs serve the gas pipeline:

- Kutubu MLV
- Gobe MLV
- Gobe Production Facility (GPF) Metering Station
- Kopi Scraper Station
- Two Cathodic Protection (CP) Stations

A summary of the services located at the AGIs is shown in Table 5-2.

Associated gas from the Kutubu CPF and the GPF ties in with the gas pipeline at the Kutubu MLV and Gobe MLV, respectively.

The Kutubu MLV, Gobe MLV and the MLV at the Kopi Scraper Station enable isolation of discrete sections of the gas pipeline in case of repair or emergency. The MLVs are spaced to reduce the volume of gas release should it occur. A diagram of the Kutubu MLV is shown in Figure 5-7.

Table 5-2: Services at gas pipeline Above Ground Installations

SERVICE	FACILITY					
	KUTUBU MLV	GOBE MLV	GPF METERING STATION	KOPI SCRAPER STATION	CP 1	CP 2
Generator	✓	✓		✓	✓	✓
Pig receiver	Future	✓		✓		
Pig launcher			✓			✓
Blowdown vent	✓			✓		
CP	✓	✓		✓	✓	✓
Condensate drain tank						
Helipad	✓	✓		✓	✓	✓
Emergency accommodation	✓	✓		✓	✓	✓

The MLVs can be operated locally or remotely controlled from the HGCP and the LNG Plant, and include an actuated shutdown valve with a bypass containing isolation valves and pipe blowdown vents. The buildings house an equipment shelter, emergency accommodation shelter and a diesel generator. A helipad is provided to facilitate access by air.

The GPF Metering Station houses one metering skid which measures the volume of associated gas being delivered from the GPF to the gas pipeline. A pig receiver is located at the GPF Metering Station to receive pigs launched at the GPF. Power and water are provided from adjacent OSL facilities.

The Kopi Scraper Station enables the gas pipeline to be cleaned and the physical integrity of the gas pipeline to be monitored. It includes a pig launcher and receiver as well as an MLV, a pipeline blowdown vent and two cathodic protection beds. It also includes an equipment shelter, emergency accommodation and a generator. A diagram of the Kopi Scraper Station is shown in Figure 5-8.

CP1 and CP2 provide additional cathodic protection beds and include equipment, emergency accommodation and generators.

5.15 Associated gas pipelines

Associated gas from the oilfield operated by OSL at Kutubu is delivered to the gas pipeline via a DN 200 (8-inch) diameter pipeline (the Kutubu Gas Pipeline). This pipeline is approximately 2.4 kilometres long and is located within the same RoW as the condensate pipeline from the CPF Metering Station to the tie-in at the Kutubu MLV. There is no pigging of the Kutubu Gas Pipeline.

Associated gas from the oilfield operated by OSL at Gobe is delivered to the gas pipeline via a DN 250 (10-inch) diameter pipeline (the Gobe Gas Pipeline), which follows the road from the GPF Metering Station to the Gobe MLV, over a distance of approximately 9.5 kilometres. The Gobe Gas Pipeline is pigged approximately twice per year via pig launchers at the GPF Metering Station and a pig receiver at the Gobe MLV.

The routes of the Kutubu Gas Pipeline and the Gobe Gas Pipeline are shown in Figure 1-2.

5.16 Pipeline and Above Ground Installation access tracks

Several access tracks put in place during construction of the condensate and gas pipelines are required during production and remain in place. The access tracks are described in Section 17.0.

Figure 5-1: Hides Wellpads and Hides Wellpad Access Road layout

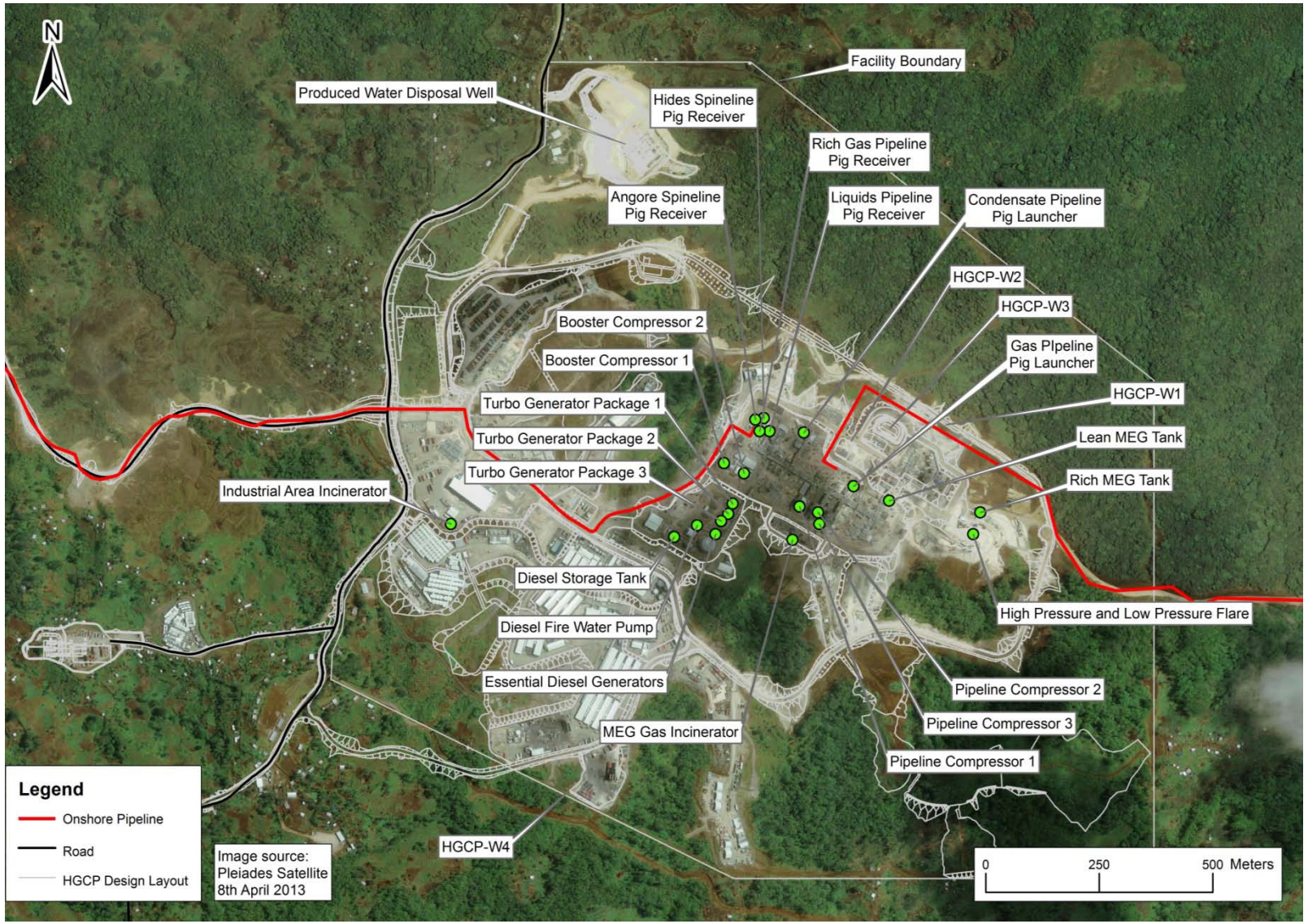

Figure 5-2: Hides Gas Conditioning Plant layout

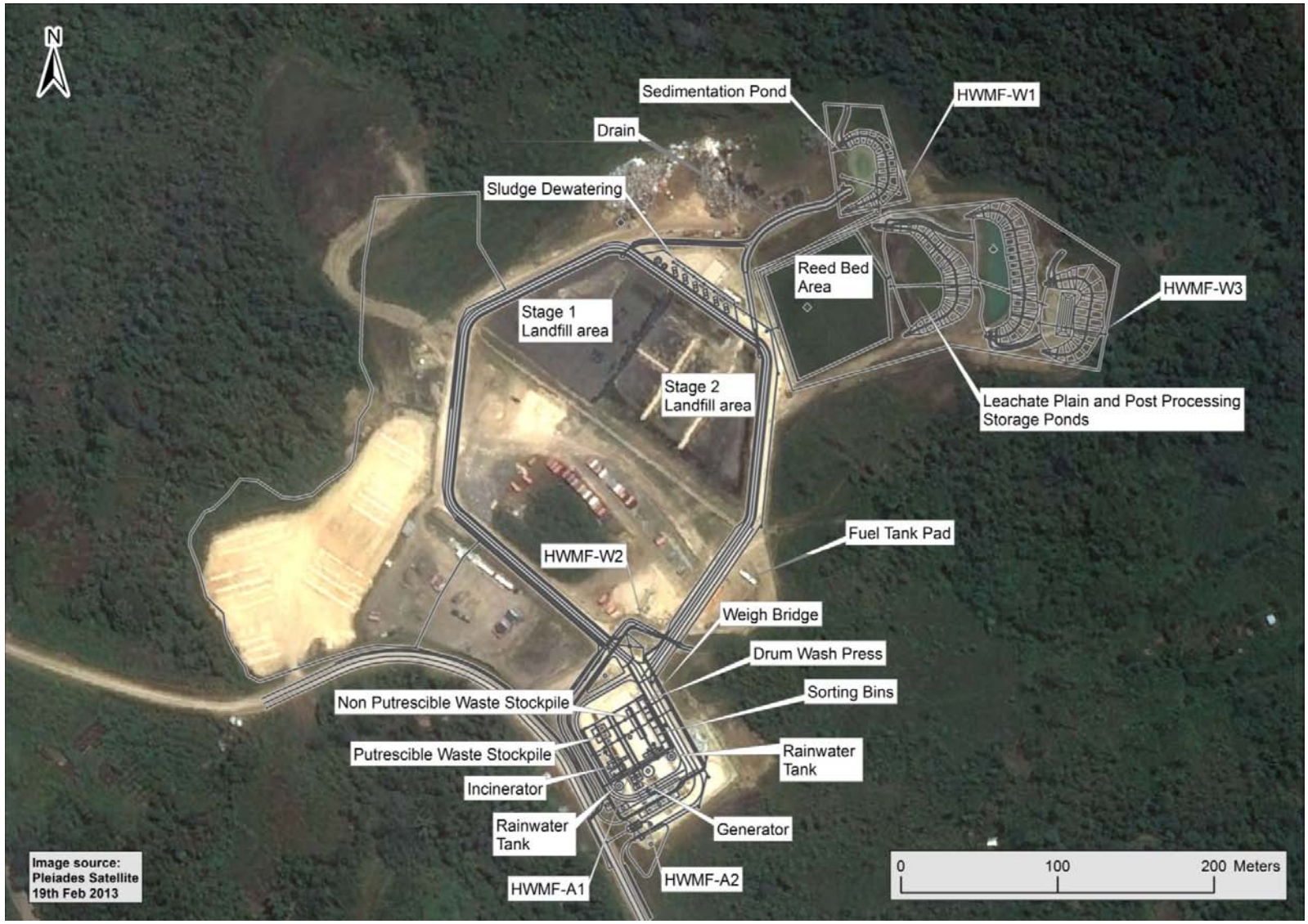

Figure 5-3: Hides Waste Management Facility layout

Figure 5-4: Hides Vehicle Wash Facility layout

Figure 5-5: Komo Airfield layout

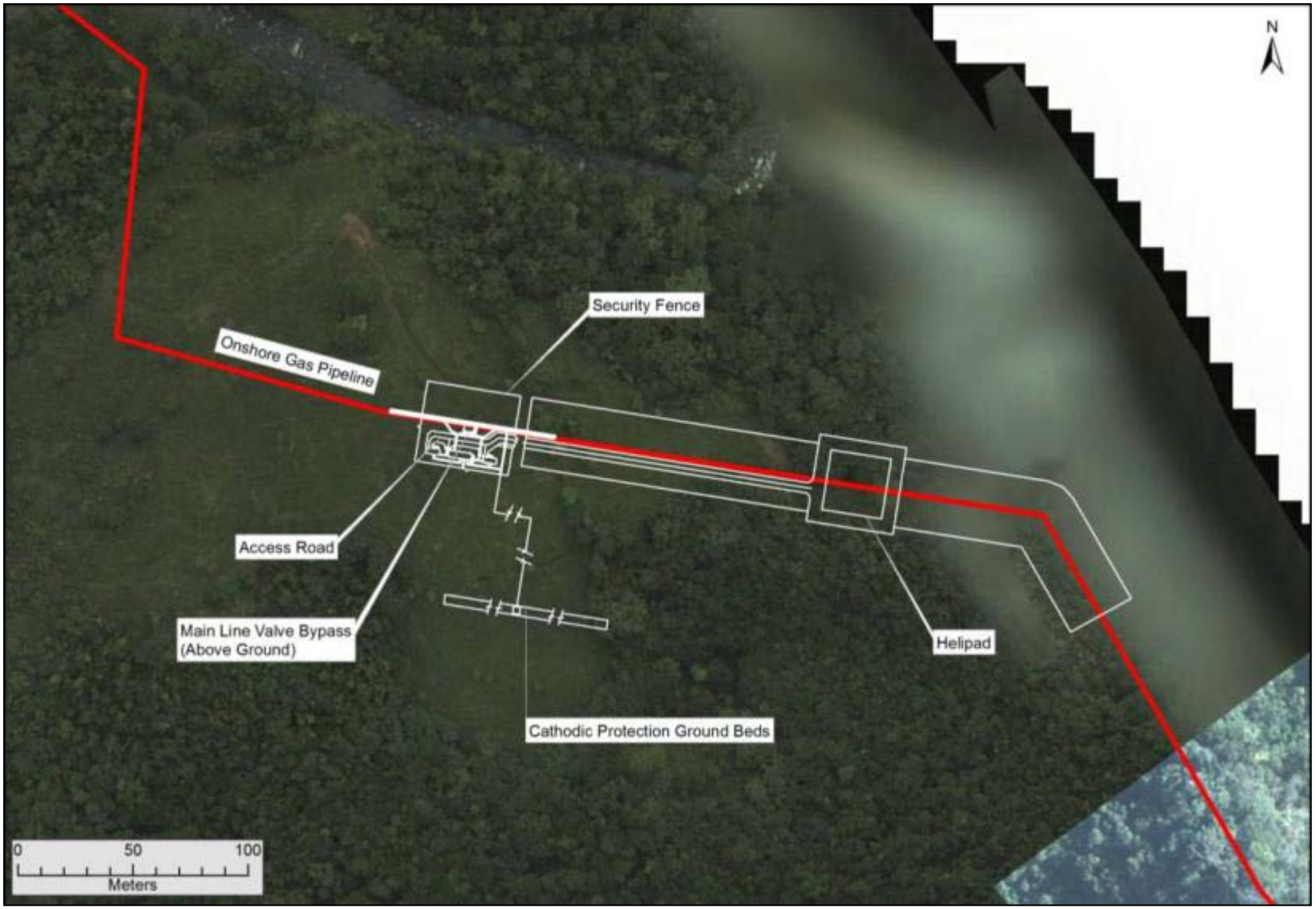

Figure 5-6: Main Line Valve 1 layout

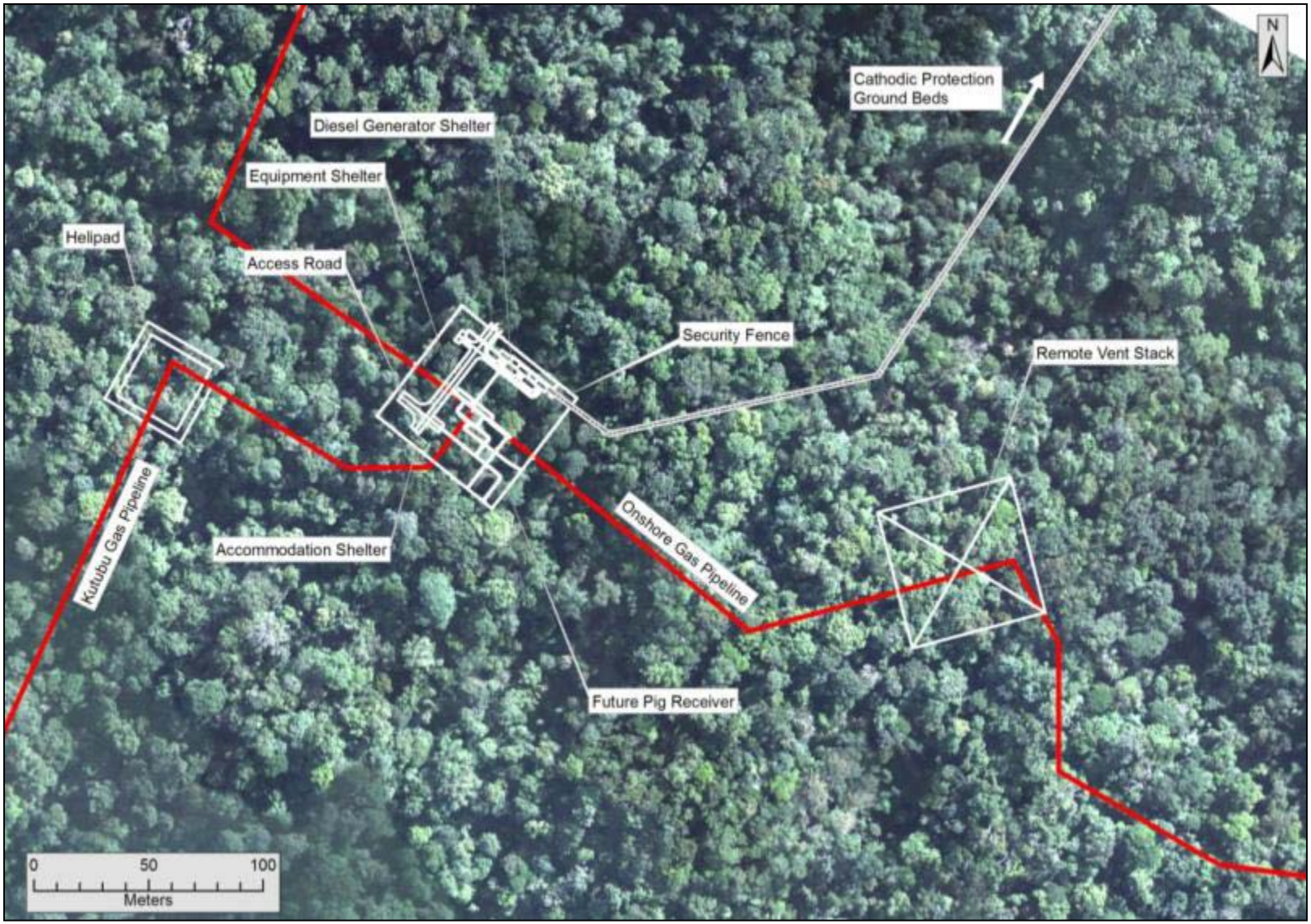

Figure 5-7: Kutubu Main Line Valve layout

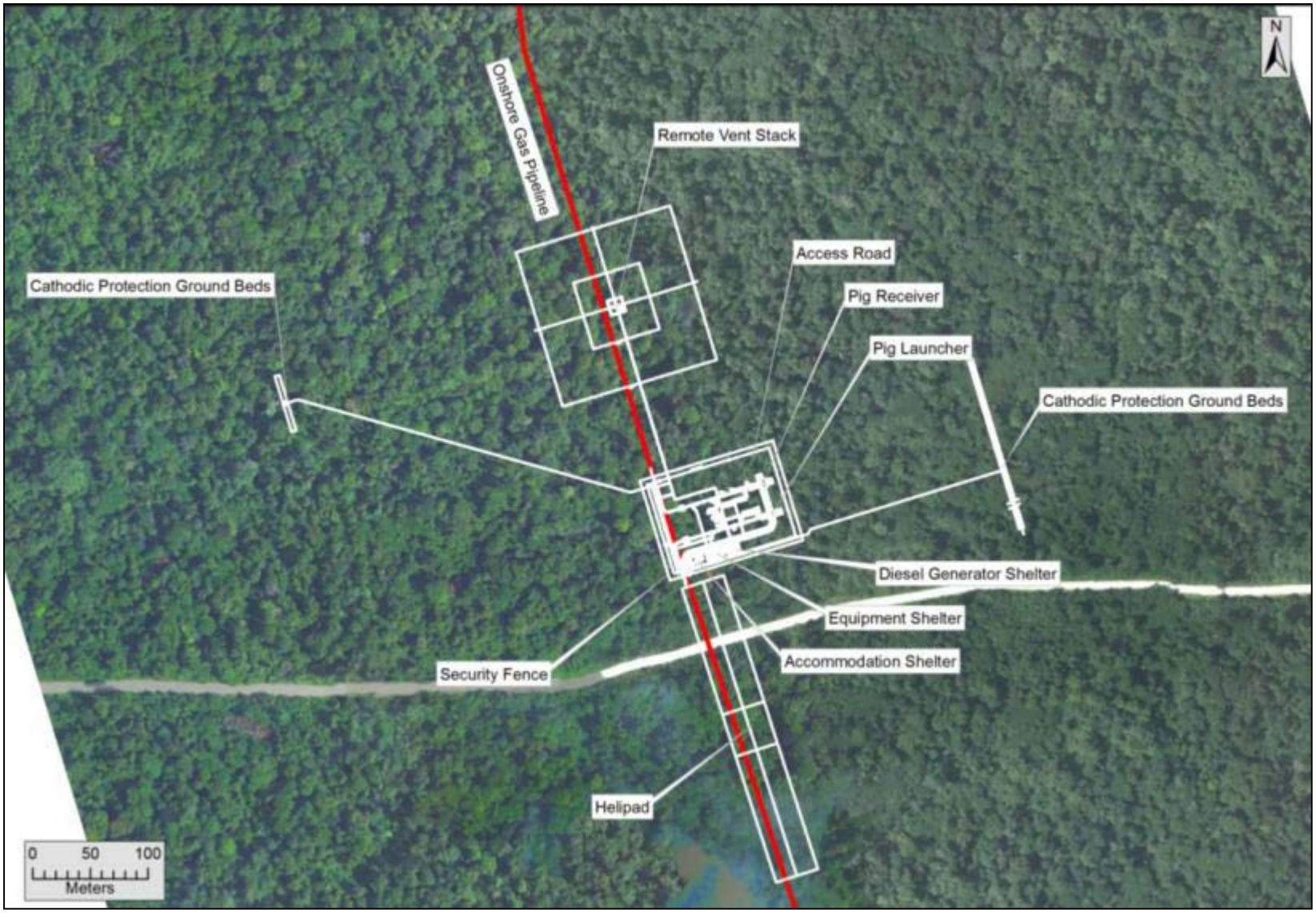

Figure 5-8: Kopi Scraper Station layout

6.0 EMISSIONS TO AIR

EHL'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.

Ambient air quality is discussed in Section 7.0.

Provisions for emissions monitoring are set out in Section 19.0.

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

6.1 Hides and Angore Wellpads

Emissions from the Hides and Angore Wellpads are associated with the pig launchers and vent knockout pots/drums located at each wellpad. The pig launchers are operated intermittently as required.

Emissions are intermittent and *de minimis*[1] and not considered further in this EMP.

6.2 Produced Water Reinjection Well

There are no emissions to air from the PWRW.

6.3 Hides Gas Conditioning Plant

Emission sources at the HGCP, 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 5-2, followed by a description of each emission source, applicable emissions criteria and control measures, including design and operational controls.

Table 6-1: HGCP emissions sources

SOURCE	EMISSION POINT REFERENCE	TYPE
Compressor Gas Turbine/Waste Heat Recovery Unit 1	HGCP-A1	Continuous
Compressor Gas Turbine/Waste Heat Recovery Unit 2	HGCP-A1	Continuous
Compressor Gas Turbine/Waste Heat Recovery Unit 3	HGCP-A1	Continuous
Main Power Generator 1	HGCP-A2	Continuous
Main Power Generator 2	HGCP-A2	Continuous
Main Power Generator 3	HGCP-A2	Continuous
MEG Vent Gas Incinerator	HCGP-A3	Continuous
Low Pressure Flare Stack (Purge and Pilot Gas)	HGCP-A4	Continuous
Low Pressure Flare Stack	HGCP-A4	Pressure Relief
Produced Water Skimmer/Degasser (to Low Pressure Flare)	HGCP-A4	Intermittent
Flotation Unit (to Low Pressure Flare)	HGCP-A4	Intermittent
Slop Oil Tank (to Low Pressure Flare)	HGCP-A4	Intermittent

[1] 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.

SOURCE	EMISSION POINT REFERENCE	TYPE
High Pressure Flare Stack (Purge and Pilot Gas)	HGCP-A5	Continuous
High Pressure Flare Stack	HGCP-A5	Pressure Relief
Spineline Pig Receiver (to High Pressure Flare)	HGCP-A5	Intermittent
Condensate Pipeline Pig Launcher (to High Pressure Flare)	HGCP-A5	Intermittent
Gas Pipeline Pig Launcher (to High Pressure Flare)	HGCP-A5	Intermittent
Slop Oil Tank Pressure Vacuum Safety Valve	HGCP-A6	Pressure Relief
Produced Water Buffer Tank 1 Pressure Control Valve	HGCP-A7	Pressure Relief
Produced Water Buffer Tank 2 Pressure Control Valve	HGCP-A7	Pressure Relief
Produced Water Buffer Tank 1 Pressure Vacuum Safety Valve	HGCP-A8	Pressure Relief
Produced Water Buffer Tank 2 Pressure Vacuum Safety Valve	HGCP-A8	Pressure Relief
MEG Flash Drum Pressure Control Valve	HGCP-A9	Pressure Relief
Lean MEG Storage Tank Pressure Control Valve	HGCP-A10	Pressure Relief
Lean MEG Storage Tank Pressure Vacuum Safety Valve	HGCP-A11	Pressure Relief
Diesel Storage Tank Atmospheric Vent	HGCP-A12	Continuous
Diesel Firewater Pump Day Tank Atmospheric Vent	HGCP-A13	Continuous
Corrosion Inhibitor Tank Atmospheric Vent	HGCP-A14	Continuous
Reverse Demulsifier Tank Atmospheric Vent	HGCP-A15	Continuous
Oxygen Scavenger Tank Atmospheric Vent	HGCP-A16	Continuous
Biocide Tank Atmospheric Vent	HGCP-A17	Continuous
Drag Reducing Agent Storage Atmospheric Vent	HGCP-A18	Continuous
Essential Services Generator 1	HGCP-A19	Intermittent
Essential Services Generator 2	HGCP-A20	Intermittent
Diesel Firewater Pump Engine	HGCP-A21	Intermittent
Industrial Waste Incinerator	HGCP-A22	Intermittent

6.3.1 Compressor gas turbine exhausts

Gas is compressed to the required gas pipeline inlet pressure via the pipeline compression system consisting of compression packages operating in parallel, each including a gas turbine driven two-stage centrifugal compressor. The compressor drivers are fitted with dry low emission combustion systems.

Fuel gas is supplied directly from the Dew Point Conditioning Unit. Hot exhaust gases from the gas turbines are directed to Waste Heat Recovery Units (WHRUs), which provide heating for the HGCP hot oil system.

During steady state operations, emissions from the three WHRU stacks are continuous and the relevant pollutant is oxides of nitrogen. Table 6-2 shows the design emissions specification for the compressor gas turbines/WHRU 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: Based on *General Environmental, Health and Safety (EHS) Guidelines (IFC, 2007)*, Table 1.1.2 - Small Combustion Facilities Emissions Guidelines. Emission guideline values stated in parts per million (ppm). Emission guideline values at reference conditions of 15 percent oxygen, dry gas. Emission guideline values apply during steady state operations, and not to start-up, shut-down and abnormal operations.		

The stack height of each WHRU is 33 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.

6.3.2 Main power generator exhausts

The main power generators supply electrical power to the HGCP and the Hides Wellpads through a low and high voltage electrical distribution network. The system consists of three dual fuel, dry, low emission combustion turbine generators.

Two turbine generators operate in parallel, with one spare. Fuel gas is supplied to each turbine generator from the Dew Point Conditioning Unit via a dedicated fuel gas conditioning system. Automatic switch to back-up diesel fuel is provided in the event of a fuel gas supply problem, with diesel supplied via transfer line direct from the HGCP Diesel System.

During steady state operations, emissions from the turbine generators are continuous and the relevant pollutant is oxides of nitrogen. 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: Based on *General Environmental, Health and Safety (EHS) Guidelines (IFC, 2007)*, Table 1.1.2 - Small Combustion Facilities Emissions Guidelines. Emission guideline values at reference conditions of 15 percent oxygen, dry gas. Emission guideline values apply during steady state operations, and not to start-up, shut-down and abnormal operations.		

The stack on each turbine generator is 19 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.

Whilst operating with diesel as a back-up fuel, emissions of oxides of sulphur from the turbine generators are relevant. *General Environmental, Health and Safety (EHS) 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 HGCP diesel system where commercially available and not cost prohibitive.

6.3.3 MEG Vent Gas incinerator

Regeneration of MEG at the HGCP involves distillation of rich MEG and produces vapours/vent gas, consisting mainly of water with some hydrocarbons (<1 percent) including benzene, toluene, ethylbenzene, and xylene (BTEX) components.

To ensure safe disposal, this vent gas is directed, via a vent gas blower, to a high temperature MEG Vent Gas (MEGVG) incinerator. The MEGVG incinerator is fuel gas fired and is sized to handle the maximum flow of vent gas during operation of both MEG regeneration units.

The MEGVG incinerator is designed to attain a combustion temperature in excess of 750 degrees Celsius to achieve thermal destruction of BTEX (the incinerator has a design 98 percent destruction efficiency). There are no applicable emission guideline values.

The MEGVG incinerator stack height is 30 metres above grade which, in addition to the destruction efficiency of the system, serves to control ground level concentrations of BTEX in ambient air.

6.3.4 Industrial park incinerator

A high temperature incinerator operates at the HGCP to dispose of combustible waste streams. The incinerator has a capacity of 100 kilograms per hour. It is diesel fired, with diesel supplied to the burners from the HGCP Diesel System.

The incinerator is of dual combustion chamber design, with the combustion temperature in both chambers 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 incinerators is treated through a pollution control system consisting of an air quench, wet spray quench, and gas cleaning system. The temperature of the flue gases exiting the secondary combustion chamber is quenched in the air quench, further cooled by the water spray quench, with final cooling by a secondary air quench. The cooled flue gas is directed to a gas cleaning system consisting of a baghouse filter for the removal of particulates and adsorption of acid gas. Filters in the bag house remove particulates and acid gas is adsorbed by injection of a mixture of pulverised hydrated lime.

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

Table 6-4: 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
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 to start-up, shut-down 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.

6.3.5 Flare system

A low pressure flare and a high pressure flare operate at the HGCP. There is no routine flaring during steady state operations; however there are certain continuous, intermittent and relief-case emissions from both flare stacks, described below.

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

Discharges from the slop oil tank, produced water skimmer/degasser and flotation unit are intermittently directed to the low pressure flare, resulting in intermittent and *de minimis* emissions.

Discharges from the Hides Spineline pig receiver, condensate pipeline launcher and gas pipeline are intermittently directed to the high pressure flare, resulting in intermittent and *de minimis* emissions.

During start-up, shut-down and conditions of excessive pressure, the low pressure flare system provides relief from equipment operating at low pressure (below 1,000 kilopascals) and the high pressure flare system provides relief from equipment operating at high pressure (reliefs, vents and blowdown with a pressure greater than 1,000 kilopascals).

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

The flares are designed to achieve up to 99 percent thermal destruction efficiency and are designed for smokeless flaring over their operating range. The flare tips are located at 97 metres above grade which, in addition to the high efficiency design, serves to control ground level concentrations of pollutants in ambient air. The high pressure flare is fitted with a high pressure sonic tip to control noise emissions.

6.3.6 Pressure Control Valves and Pressure Vacuum Safety Valves

A number of Pressure Control Valves and Pressure Vacuum Safety Valves operate at the HGCP to provide pressure relief. Emissions from the Pressure Control Valves are intermittent and *de minimis* and are not considered further in this EMP. Emissions from the Pressure Vacuum Safety Valves are not routine (only in case of pressure relief), *de minimis* and not considered further in this EMP.

6.3.7 Atmospheric vents

A number of atmospheric vents operate at the HGCP. Emissions from these vents are *de minimis* and are not considered further in this EMP.

6.3.8 Diesel engines

Essential services generators are available for start-up or when main power generators are unavailable, catering for essential loads at the HGCP and Hides Wellpads. A diesel engine driven firewater pump is provided as back up to the electrically driven primary firewater pump. For maintenance purposes, generators and firewater pump engines are operated for several hours per week. Emissions from the diesel engines are intermittent and *de minimis* and are not considered further in this EMP.

6.4 Hides Waste Management Facility

Emission sources at the HWMF, including continuous and intermittent sources during normal and abnormal operating conditions, are listed in Table 6-5. The location of each emission source is shown in Figure 5-3, followed by a description of each source, applicable emissions criteria and control measures, including design and operational controls.

Table 6-5: Hides Waste Management Facility emissions sources

SOURCE	EMISSION POINT REFERENCE	TYPE
Incinerator	HWMF-A1	Intermittent
Diesel engine generators	HWMF-A2	Continuous

6.4.1 Incinerator

The main source of emissions to air at the HWMF is a high temperature incineration package, which operates to process combustible waste streams. Waste management is further discussed in Section 12.0.

The incineration package is diesel fired, with diesel supplied to the burners via a reticulation line from a diesel day storage tank.

The incinerators are of dual combustion chamber design, which enables optimum combustion and destruction of pollutants, with the combustion temperature in both chambers 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 incinerators is treated through a pollution control system consisting of a primary air quench, wet spray quench, secondary air quench and gas cleaning system.

The temperature of the flue gases exiting the secondary combustion chamber of each incinerator is immediately quenched in the primary air quench. Flue gas is then directed to the water spray quench for further cooling and subsequently to the secondary air quench unit for final cooling.

The cooled flue gas from each incinerator train's water spray quench chamber is combined and directed to a common gas cleaning system consisting of a baghouse filter for the removal of particulates and adsorption of acid gas. Filters in the bag house remove particulates and acid gas is adsorbed through the injection of a mixture of pulverised hydrated lime and powder activated carbon.

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

The stack on each incinerator is 16 metres above grade which, in addition to the combustion efficiency and pollution control system, serves to control ground level concentrations of pollutants in ambient air.

6.4.2 Diesel engines

Generators driven by diesel engines operate at the HWMF to provide power to the facility. One generator operates continuously, with the other providing additional duty when necessary. Polluting emissions from the diesel engines are oxides of nitrogen, carbon monoxide, and sulphur dioxide.

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 control the release of pollutants. Low sulphur diesel will be used where commercially available and not cost prohibitive.

6.5 Hides Vehicle Wash Facility

Diesel engine driven generators operate at the HVWF to provide power to the Facility. One generator operates continuously, with the other providing additional duty when necessary. Polluting emissions from the diesel engines are oxides of nitrogen, carbon monoxide, and sulphur dioxide. In the absence of emission guideline values applicable to the operation of the diesel engine generators, a program of preventive maintenance ensures the generators operate in accordance with manufacturer specifications and control release of pollutants. Low sulphur diesel is used where commercially available and not entailing excessive cost.

6.6 Komo Airfield

Emission sources at Komo Airfield, including continuous and intermittent sources during normal and abnormal operating conditions, are listed in Table 6-6. The location of each emission source is shown in Figure 5-5, followed by a description of each source, applicable emissions criteria and control measures, including design and operational controls.

Table 6-6: Komo Airfield emissions sources

SOURCE	EMISSION POINT REFERENCE	TYPE
Diesel engine generators	KA-A1	Continuous
Essential services generators	KA-A2	Intermittent
Firewater pump diesel engines	KA-A3	Intermittent
Aircraft emissions	N/A	Intermittent
NOTE: KA = Komo Airfield		

6.6.1 Diesel engines

Generators driven by diesel engines operate at the Komo Airfield to provide power to the facility. The power generation system comprises several diesel engine generators. Three generators provide power, with one generator operating continuously, another providing additional duty when necessary, and a third providing redundancy. Polluting emissions from the diesel engines are oxides of nitrogen, carbon monoxide, and sulphur dioxide.

In the absence of emission guideline values applicable to the operation of the diesel engine generators, preventive maintenance ensures they operate in accordance with manufacturer specifications and control release of pollutants. Low sulphur diesel is used where commercially available and not cost prohibitive.

An essential services generator is available at the Komo Airfield as back up to the main power generators, catering for essential loads including runway lighting and navigation aids. For maintenance purposes, the essential services generator is operated for up to two hours per week. Emissions from the essential services generator are intermittent and *de minimis* and are not considered further in this EMP.

Four diesel engine driven firewater pumps are provided to serve the Komo Airfield fire protection system. For maintenance purposes, the firewater pumps are operated for up to two hours per week. Emissions from the firewater pumps are intermittent and *de minimis* and are not considered further in this EMP.

6.6.2 Aircraft emissions

The Komo Airfield serves operations of fixed and rotary wing aircraft and is primarily used for the transport of personnel. Due to the low frequency and short duration of aircraft movements, aircraft emissions are considered to be intermittent and *de minimis* and are not considered further in this EMP.

6.7 Pipelines and Above Ground Installations

There are no significant emission sources during operation of the pipelines and AGIs, with the main source being diesel engine generators.

6.7.1 Emissions from diesel engines

Generators driven by diesel engines operate at the MLVs, the Kopi Scraper Station and the CP Stations.

At all sites, the diesel engine generators operate daily for approximately eight hours. Acoustic attenuation devices will be installed on the generators as appropriate.

Polluting emissions from the diesel engine generators are oxides of nitrogen, carbon monoxide, and sulphur dioxide.

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 control release of pollutants. Low sulphur diesel will be used where commercially available and not cost prohibitive.

6.7.2 Emissions from blowdown vents

Blowdown vents at the Gobe MLV, Kutubu MLV and Kopi Scraper Station will operate should the gas pipeline require depressurisation during upset conditions, such as in the event of a release or other damage to the pipeline. Depressurisation, which involves emptying the pipeline of gas in isolated sections, is considered an unlikely event.

Emissions from the depressurisation process are not routine (only in case of pressure relief) and *de minimis* and are not considered further in this EMP.

6.8 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 during operation of the facilities within the scope of this EMP.

Minor fugitive emissions arise from pig receivers and launchers, pipeline blowdown vents, diesel storage tanks and the condensate drain at the CPF Metering Station. These types of emissions are *de minimis* and are not considered further in this EMP.

6.9 Dust

Dust may be generated in dry conditions. To reduce the occurrence of dust, appropriate vehicle speed limits are applied within EHL facilities and on public roads. In the event that dust causes a nuisance, appropriate control measures (for example road dampening) will be implemented.

6.10 Light

Light has the potential to disturb nocturnal fauna. Potential impacts of perimeter and other lights will be reduced by directing light to where it is required for operations and security and where practical avoid directing it to surrounding areas.

7.0 AMBIENT AIR QUALITY

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

The ambient air quality guidelines applicable to EHL's operations are described in this section. Ambient air quality monitoring is discussed in Section 19.0.

Emissions to atmosphere from the Upstream Facilities, Infrastructure and Pipelines 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 *Ambient Air Quality Guidelines (World Health Organization, 2006)*, as cited in the *General Environmental, Health and Safety (EHS) 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 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

EHL'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 Upstream Facilities has the potential to cause localised noise impacts to nearby receptors. Noise guidelines applicable to steady state operation of the Upstream Facilities are shown in Table 8-1.

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 *General Environmental, Health and Safety (EHS) Guidelines (IFC, 2007)*, Table 1.7.1 Noise Level Guidelines. 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. 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 perimeter fence line of each facility. The perimeter fence and the layout of noise generating equipment at each facility have been designed to achieve these criteria.

The criteria shown in Table 8-1 will be achieved without consideration of background noise (i.e. 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 19.0.

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.

9.0 DISCHARGES TO WATER AND WATER QUALITY

EHL'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 19.0.

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

9.1 Hides and Angore Wellpads

There are no discharges to water from the Hides Wellpads or Angore Wellpads.

Stormwater from uncontaminated areas runs directly off without collection; that is there is no point source discharge.

Water collected in the vent knockout drum drains (open drain sump) is collected periodically and transferred to the open drain sump at the HGCP.

9.2 Produced Water Reinjection Well

Formation water produced from the well stream will be separated at the HGCP and sent to a produced water disposal well. Prior to injection, the produced water will pass through two filters designed to remove course and fine sediment from the water. Retained and backwashed water from the filters will be routed to the beginning of the produced water train to form a closed loop. No produced water will be disposed of external to the well stream process train.

9.3 Hides Gas Conditioning Plant

Discharges to water at the HGCP are listed in Table 9-1. The location of each emission source is shown in Figure 5-2, followed by a description of each source and the relevant control measures, including design and operational controls.

Table 9-1: Hides Gas Conditioning Plant discharge points

SOURCE	DISCHARGE POINT REFERENCE	TYPE
Stormwater	HGCP-W1	Intermittent
Open drain system	HGCP-W2	Intermittent
Retention pond	HGCP-W3	Intermittent
Wastewater Treatment Plant (WWTP)	HGCP-W4	Intermittent

9.3.1 Open and closed drain systems

The drain system at the HGCP enables separate management of clean and potentially contaminated water.

A stormwater system collects stormwater from uncontaminated areas at the HGCP and discharges directly to the environment without treatment at several locations.

An open drain system collects stormwater, washdown, spillage, and firewater from potentially contaminated areas at the processing facility and discharges to an open drain sump.

The open drain sump provides retention time for initial solids separation, oily water separation, and a corrugated plate interceptor to further separate oily water. Separated oil

from the open drain sump is collected via a weir system and pumped to a slop oil tank, and separated water is directed to the retention pond.

For those areas which contain significant volumes of MEG (including the MEG regeneration package area and the MEGVG incinerator area) stormwater is retained in a first flush containment sump, enabling it to be checked for MEG contamination. MEG-contaminated water is removed from the sump via vacuum truck and disposed of either to the PWRW or to the HWMF. Uncontaminated stormwater is directed to the open drain sump.

For those areas which contain bulk lube oil (for example the compressor gas turbine area and main power generator area) or where chemicals are required to be drained, a lube oil and chemical drain discharges directly to the closed drain system.

The closed drain system connects to a closed drain header and subsequently to the low pressure flare drum. The contents of the low pressure flare drum are periodically directed to the slop oil tank. The contents of the slop oil tank are periodically directed to the HGCP inlet separation system.

9.3.2 Retention pond

The retention pond receives discharges from the open drain sump. It provides retention time to further separate (settle) sediment and also further separate residual oils and greases, which are manually skimmed from the surface using a portable device and directed back to the open drain sump (upstream of the corrugated plate interceptor).

Water entering the retention pond flows past a weir to ensure the stable water level in the retention pond is not disturbed. The retention pond is provided with a high density polyethylene liner to prevent release of its contents to the environment. Clean water from the retention pond is discharged to the environment via the HGCP stormwater system.

9.3.3 Sewage

A packaged WWTP operates at the HGCP to treat domestic wastewater. The WWTP is based on activated sludge technology and has a capacity of 180 cubic metres per day.

9.4 Hides Waste Management Facility

Discharges to water at the HWMF are listed in Table 9-2. The location of each discharge source is shown in Figure 5-3, followed by a description of each source and the relevant control measures, including design and operational controls.

Table 9-2: Hides Waste Management Facility discharge points

SOURCE	DISCHARGE POINT REFERENCE	TYPE
Stormwater	HWMF-W1	Intermittent
Process building	HWMF-W2	Intermittent
WWTP	HWMF-W3	Intermittent

9.4.1 Stormwater

Stormwater from uncontaminated areas at the HWMF is discharged directly to the environment without treatment at several locations.

9.4.2 Process building wastewater

Wastewater from potentially contaminated areas is drained to an initial treatment system which provides retention time for solids separation, and oily water separation. The partially treated wastewater then drains by gravity to the leachate treatment system.

9.4.3 Sludge dewatering system

A sludge dewatering system operates at the HWMF to dewater sludge received from the WWTP in the Hides area. It consists of six geotubes and skips, a sludge holding tank, a thickener tank and an ozone treatment and rainwater collection tank. Sludge is routed to the landfill for final disposal and effluent is pumped to the leachate treatment system.

9.4.4 Leachate treatment system

The leachate treatment system receives effluent from the process building, sewage sludge dewatering system and landfill leachate. Leachate from the landfill collects in a sump at the low point of the landfill and is manually pumped to the leachate treatment system.

The leachate treatment system consists of a series of sediment ponds and a reed bed system, where treatment is achieved by directing the leachate through a bed of reeds which take up water, nutrients and heavy metals from the leachate.

9.5 Hides Vehicle Wash Facility

There are no discharges to water from the HVWF, which operates using a closed loop system, where all wash water is recycled.

Stormwater from uncontaminated areas runs directly off without collection.

9.6 Komo Airfield

Discharges to water at the Komo Airfield are listed in Table 9-3. The location of each discharge source is shown in Figure 5-5, followed by a description of each source and the relevant control measures, including design and operational controls.

Table 9-3: Komo Airfield discharge points

SOURCE	DISCHARGE POINT REFERENCE	TYPE
Stormwater	KA-W1	Intermittent
Open drain system	KA-W2	Intermittent
WWTP	KA-W3	Intermittent
NOTE: KA = Komo Airfield		

9.6.1 Stormwater

A stormwater system collects stormwater from uncontaminated areas at the Komo Airfield and discharges directly to the environment without treatment at several locations.

9.6.2 Open drain system

An open drain system collects stormwater, washdown, spillage, and firewater from potentially contaminated areas at the Komo Airfield, including the hangar building, aircraft refuelling area locations on the apron, helicopter pads and fuel depot. The open drain system discharges to open drain sumps, which provide retention time for oily water separation. Separated oil from the open drain sumps will be collected periodically and transferred to the HWMF for treatment and disposal.

9.6.3 Sewage

A packaged WWTP operates at the Komo Airfield to treat domestic wastewater generated on-site at the guard house, terminal, hangar and fire station buildings. Wastewater from these buildings is pumped to the WWTP. The WWTP has a capacity 5,000 litres per day and provides biological treatment followed by ultrafiltration membrane and ultraviolet disinfection.

Treated wastewater from the WWTP is discharged to the environment via the Komo Airfield stormwater system. Sludge from the WWTP will be stored and transferred to the HWMF for treatment and disposal.

9.7 Pipelines and Above Ground Installations

There are no discharges to water during operation of the pipelines and AGIs. Environmental aspects to consider are stormwater run-off and domestic wastewater.

9.7.1 Stormwater

Stormwater from uncontaminated areas at the AGIs runs directly off to the environment without collection, that is there are no point source discharges.

Wastewater from potentially contaminated areas drains to collection sumps and will be removed as required for treatment and disposal at an EHL approved facility.

9.7.2 Domestic wastewater

Although the AGIs are not normally manned, emergency accommodation is provided at the MLV, Kopi Scraper Station and CP Stations. A septic pit is provided to receive domestic wastewater. The contents of the septic pit will be removed as required for treatment and disposal at an EHL approved facility.

9.8 Wash water

The washing of equipment, vehicles or machinery near or within watercourses is prohibited.

9.9 Water quality and discharge criteria

9.9.1 Water quality criteria

Annex 2 of EHL's Environment Permit sets out applicable fresh water quality criteria, as shown in Table 9-4 and Table 9-5. Discharges to receiving waters should not cause a lowering of receiving water quality below the criteria shown in Table 9-4. Table 9-5 shows maximum permitted criteria of ammonia-nitrogen for protection of freshwater aquatic life.

Table 9-4: Water quality criteria

PARAMETER	WATER QUALITY CRITERIA (FRESHWATER)
pH	6.5 – 9 (pH units)
Temperature	No alteration greater than 2 degrees Celsius
Turbidity	No alteration greater than 25 NTU or no change > 10 percent from background levels at any particular time (whichever is greater)
Total Suspended Solids	50 mg/L or no change > 10 percent from background levels at any particular time (whichever is greater)
Insoluble residues	No insoluble residues or sludge formation to occur
Dissolved oxygen	Not less than 6 mg/L or no change > 10 percent from background levels at any particular time (whichever is greater)
Chemical oxygen demand	125 mg/l
Biological oxygen demand	25 mg/l
Sulphate as $SO4^{2-}$	400 mg/l
Sulphide as HS-	0.002 mg/l
Ammonia-nitrogen	Dependent on pH and temperature (Table 9-5)
Nitrate	45 mg/l
Potassium	5.0 mg/l
Barium	1.0 mg/l

PARAMETER	WATER QUALITY CRITERIA (FRESHWATER)
Boron	1.0 mg/l
Cadmium	0.01 mg/l
Chromium (as hexavalent)	0.05 mg/l
Cobalt	Limit of detection
Copper	1.0 mg/l
Iron	1.0 mg/l
Lead	0.005 mg/l
Manganese	0.5 mg/l
Mercury	0.0002 mg/l
Nickel	1.0 mg/l
Selenium	0.01 mg/l
Silver	0.05 mg/l
Tin	0.5 mg/l
Zinc	5.0 mg/l
Oil and grease	No visible film (for construction discharges) 10 mg/l (for production discharges)
Phenols	0.002 mg/l
Faecal coliform	Not to exceed 200 colonies per 100 ml or no change > 10 percent from background levels at any particular time (whichever is greater)

Source: Annex 2 of EHL's 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).

NTU = nephelometric turbidity unit.

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

The criteria for faecal coliform bacteria is based on not fewer than five water samples collected over not more than a 30-day period.

Table 9-5: Water quality criteria: ammonia-nitrogen

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 EHL's Environment Permit, based on *Environment (Water Quality Criteria) Regulation 2002*, Water Quality Criteria for Aquatic Life Protection.

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

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 for the Project does not specify a mixing zone.

9.9.2 Discharge criteria: stormwater

Discharges of stormwater from uncontaminated areas of the Hides Wellpads, Angore Wellpads, HGCP, HWMF, HVWF and Komo Airfield 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 > 10 percent from background levels at any particular time (whichever is greater)
Dissolved oxygen	Not less than 6 mg/l or no change > 10 percent from background levels at any particular time (whichever is greater)
Total Suspended Solids	50 mg/l or no change > 10 percent from background levels at any particular time (whichever is greater)
Oil and grease	10 mg/l
Source: Annex 2 of EHL's 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. NTU = nephelometric turbidity unit.	

9.9.3 Discharge criteria: process wastewater

Discharges of process wastewater at the HGCP and HWMF will, at the point of discharge to surface waters, meet the criteria set out in Table 9-7.

Table 9-7: Discharge criteria: process wastewater

PARAMETER	WATER QUALITY CRITERIA
pH	6.5 – 9 (pH units)
Temperature	No alteration greater than 2 degrees Celsius
Insoluble residues	No insoluble residues or sludge formation to occur
Dissolved oxygen	Not less than 6 mg/l or no change > 10 percent from background levels at any particular time (whoever is greater)
Chemical oxygen demand	125 mg/l
Biological oxygen demand	25 mg/l
Sulphate as $SO4^{2-}$	400 mg/l
Sulphide as HS-	0.002 mg/l
Ammonia-nitrogen	Dependent on pH and temperature (Table 9-5)
Nitrate	45 mg/l
Potassium	5 mg/l
Barium	1 mg/l
Boron	1 mg/l
Cadmium	0.01 mg/l
Chromium (as hexavalent)	0.05 mg/l

PARAMETER	WATER QUALITY CRITERIA
Cobalt	Limit of detection
Copper	1 mg/l
Iron	1 mg/l
Lead	0.005 mg/l
Manganese	0.5 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
Phenols	0.002 mg/l
Source: Annex 2 of EHL's 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.	

9.9.4 Discharge criteria: Wastewater Treatment Plants

For discharges from WWTPs treating sewage at the HGCP, the discharges will, at the point of discharge to surface waters, meet the criteria set out in Table 9-8.

Table 9-8: Discharge criteria: 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	Dependent on pH and temperature (Table 9-5)
Total Suspended Solids	50 mg/l
Oil and grease	10 mg/l
Faecal coliform	Not to exceed 200 colonies per 100 ml or residual chlorine: as close as possible to 1 mg/l
Source: Based on Annex 2 of EHL's Environment Permit as deemed relevant to the discharge of WWTPs. The criteria for faecal coliform bacteria is based on not fewer than five water samples collected over not more than a 30-day period.	

9.9.5 Discharge criteria: leachate

Discharge of leachate from the landfill at the HWMF will, at the point of discharge to surface waters, meet the full set of criteria set out in Table 9-4.

10.0 SPILL PREVENTION AND RESPONSE

EHL'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 actions to be taken in the event of a spill or release, are described in this section.

The control measures set out in this section, including design and operational controls, have been developed in accordance with the requirements and using 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 EHL's facilities in the Hides area by third party suppliers primarily from Lae, Mount Hagen and other locations along the Highlands Highway. EHL will take responsibility for purchased fuel and chemicals upon receipt.

As part of the procurement process, the agreements in place between EHL and third party suppliers 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.

Transport of fuel and chemicals to the condensate pipeline and gas pipeline AGIs will generally be undertaken by EHL by road or via helicopter.

In the case of transfer by helicopter, fuel and chemicals will be transported using totes which are purposely designed for the transfer of hazardous materials. The totes will be regularly inspected and maintained as part of preventive maintenance. Flight paths will be designed to avoid populated areas where feasible.

In the case of transfer by road, fuel will be transported in purpose-built tankers with double skinned tanks 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.

Where fuel and chemicals are delivered to the AGIs by third party suppliers, EHL will take responsibility for purchased fuel and chemicals upon receipt. The above described assessment and approval process applies.

10.2 Fuel storage and transfer

Diesel storage facilities at the HGCP include the diesel system main tank, the essential services generators day tank and the firewater pump day tank. The helicopter refuelling facility includes three aviation fuel storage tanks. All storage tanks are located within 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, associated pumps and couplings, will be routinely inspected as part of preventive maintenance.

At the HWMF and the HVWF, diesel is stored in day tanks located within secondary containment sufficient to enable containment of 110 percent of the tank's inventory and supplied via an above ground transfer line to the generators.

At the Komo Airfield, a diesel day tank is located adjacent to each generator and firewater pump. The tank is located within secondary containment sufficient to enable containment of

110 percent of the tank's inventory. Diesel will be transferred to the diesel day tank using supply trucks and supplied via above ground transfer lines to the generators/pumps. Diesel is stored at a fuel depot containing two storage tanks located within secondary containment sufficient to enable containment of 110 percent of a single tank's inventory and supplied via an above ground transfer line to the generators. The Komo fuel depot also contains four aviation fuel storage tanks. The storage tanks are double walled and located within secondary containment sufficient to enable containment of 110 percent of a single tank's inventory.

Diesel fuel is stored in tanks at all MLV and CP Stations, as well as at the Kopi Scraper Station. The diesel tanks have a maximum capacity of 7 cubic metres. They are purpose-built above ground and include secondary containment sufficient to enable containment of 110 percent of the storage capacity of the largest vessel present. Integrity of fuel transfer facilities, including transfer lines and vehicles and associated pumps and couplings, will be routinely inspected as part of preventive maintenance. Diesel tanks at the AGIs will be refuelled as needed, approximately monthly. 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.

A drain tank is located at the Kutubu CPF Metering Facility to collect condensate from pigging activities. This tank has a maximum capacity of 6 cubic metres and is housed within a concrete pit below ground level to allow draining of the pigging skids via gravity. The tank is double skinned and has a visual level indicator and a level transmitter relaying to the HGCP. The tank will be emptied when required by vacuum truck and transported to the HWMF or OSL-operated facility.

10.3 Chemical storage and transfer

Chemicals are used and stored at various locations at the Hides and Angore Wellpads, HGCP, HWMF, HVWF, Komo Airfield and the condensate/gas pipeline AGIs. At all locations, chemical storage facilities are purpose-built and include appropriate secondary containment. Integrity of chemical transfer facilities, including transfer lines and vehicles and associated pumps and couplings, will be routinely inspected as part of preventive maintenance.

Most chemicals are used and stored at the HGCP, as summarised below. A mobile methanol injection package operates to counter hydrate formation (hydrates are crystals which form under certain conditions and may cause line plugging). Methanol is stored in intermediate bulk containers of 1 cubic metre, located within a bunded area.

An oxygen scavenging and biocide injection package is provided to inhibit bio-fouling and minimise oxygen induced corrosion of the PWRW and slop oil/condensate tank. The oxygen scavenger and biocide are stored in skid-mounted intermediate bulk containers of approximately 1.5 and 10 cubic metres, respectively. A reverse demulsifier package operates to chemically enhance oil separation as part of the produced water treatment process. The chemical is stored in a skid-mounted intermediate bulk container of approximately 1.5 cubic metres. A drag reduction agent package maintains the appropriate inlet pressure for the condensate pipeline. This chemical is stored in a skid-mounted intermediate bulk container of approximately 8 cubic metres. These packages are all located within bunded areas and all pumps include controlled volume metering and dual diaphragm pump heads.

Corrosion inhibitor is continuously injected into the well flowlines to prevent corrosion. The chemical is delivered to and stored at the HGCP in double-skinned containers of 20,000 litres each and transferred (pumped) to the Hides and Angore Wellpads through the MEG pipelines (MEG is used as the carrier fluid for corrosion inhibitor).

Chemicals not in use will be stored in the chemical and hazardous material storage shelter.

10.4 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. EHL will assess third party suppliers prior to approval and will review spill response arrangements. The agreements in place between EHL and third party suppliers will include minimum requirements relating to spill preparedness and response. Follow-up assessments of third parties will be undertaken periodically.

EHL will respond to a spill or release of fuel or chemical at EHL facilities, or while in transit by EHL between EHL facilities. 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 EHL to respond on-site), Tier 2 (exceeds the capability of EHL's on-site resources) and Tier 3 (exceeds available resources in Papua New Guinea and requires resources to be mobilised internationally).

EHL will respond to Tier 1 spills directly using on-site resources. In the case of a Tier 2 spill, EHL will respond using on-site resources and resources mobilised from other EHL facilities in the Hides/Komo area.

Further details about EHL's response to spills of hydrocarbons are provided in EHL'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

EHL'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

EHL 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 (The Secretariat of the Stockholm Convention, 2009)*, *Montreal Protocol on Substances that Deplete the Ozone Layer (Ozone Secretariat United Nations Environment Programme, 2000)* and *Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (Secretariat of the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, 2011)*.

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

11.3 Hazardous materials

EHL 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 is unavoidable, product-specific controls will be implemented. Controls may include engineering (such as 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

Water is taken from several permanent abstraction points in the Hides/Komo area.

There is no abstraction of water during normal operation of the pipelines and AGIs. In the case of the CPF Metering Station and GPF Metering Station, water is supplied from adjacent OSL facilities. There is no water supply to the other AGIs.

Details of the abstraction points will be maintained in a register.

Where there is potential for water abstraction from a surface water course 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, EHL 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, pursuant to the Environment Permit.

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

11.5 Aggregate and quarry material

New quarries developed by EHL or directly on behalf of EHL are permitted under the Environment Permit and additional permits are not necessary.

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 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.

Aggregate will not be sourced from any 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 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.

12.0 WASTE

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

Measures to prevent, mitigate and otherwise control potential significant environmental impacts associated with waste are described below. Information about waste 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, have been developed in accordance with the waste management requirements prescribed in OIMS System 6-5 Environmental Management.

12.1 General provisions

EHL 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.

With the exception of reuse, recycling and recovery, EHL waste 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 EHL.

Wastes are categorised as either non-restricted or restricted.

Non-restricted wastes are those that do not pose an immediate threat to health, safety and/or the environment (examples are 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 oils and greases, oil-contaminated rags, containers, filters, degreasing agents, fluorescent tubes, batteries, and health care waste).

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.

12.2 Waste avoidance and minimisation

The potential for waste generation will be 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 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 HWMF.

Restricted wastes will be separated at source at designated restricted waste collection points, which enable appropriate segregation and storage of waste pursuant to compatibility requirements. The restricted waste collection points are secure and fitted with a roof and appropriate containment to prevent release to the environment. The contents of the restricted waste collection points will be transferred periodically to the HWMF.

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 HWMF.

Combustible wastes may be transferred directly to the high temperature incinerator at the HGCP.

12.4 Waste storage

Wastes transferred to the HWMF will be verified and documented upon receipt in accordance with a waste acceptance protocol. Wastes will be screened to ensure only acceptable waste types are received. The weight of wastes will be recorded.

Wastes will then be directed to the storage area (Figure 5-3), which provides for the separate storage of non-restricted and restricted wastes in a manner which facilitates subsequent management (reuse, recycling, recovery, treatment and disposal).

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

Certain wastes will be transferred directly upon receipt at the HWMF to the point of treatment, including waste oils for incineration which will be transferred to the liquid injection pump station, and sewage sludge which will be transferred to the sludge holding tank.

Combustible wastes transferred to the high temperature incinerator at the HGCP will be verified, documented and stored as necessary prior to incineration. The storage area provides for separation pursuant to waste compatibility requirements, is covered and has appropriate containment to prevent release to the environment.

12.5 Waste reuse, recycling and recovery

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

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

12.6 Waste treatment and disposal

Wastes that cannot be reused, recycled and/or recovered will be treated and disposed of at the HWMF. Incineration may take place either at the HWMF or at the HGCP. The following are examples of waste management equipment and facilities that may be used at the HWMF: weighbridge, process building, drum crusher and cleaner, tyre debeader, shredder, sewage sludge dewatering system, incinerator package, ash stabilisation system, landfill and leachate treatment system. Specific equipment and facilities may vary during production according to need.

The treatment and disposal process 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 inert waste that is not suitable for incineration and ash residues from the incineration process)
- Leachate treatment (treatment of landfill leachate)

Each process is outlined below.

12.6.1 Treatment

Treatment of solid wastes in preparation for incineration or disposal to landfill may include crushing of metal and plastic drums, debeading of tyres, shredding of plastic drums, debeaded tyres and timber. The sewage sludge dewatering system treats sludge prior to incineration and may include geotubes, sludge holding, thickening and ozone treatment.

12.6.2 Incineration

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

12.6.3 Ash stabilisation

Bottom and fly ash from the incineration process (at both the HGCP and HWMF) 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 and directed to landfill.

12.6.4 Landfill

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 five 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 will 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 three layers. The first layer will be a landfill gas distribution layer consisting of porous material and containing a network of high density polyethylene pipes connected to landfill gas trenches that enable the venting of landfill gases. The second layer will consist of compacted soil and a geo-synthetic clay liner. The final layer will contain topsoil. The surface of the covered landfill will then be vegetated to prevent erosion.

12.6.5 Leachate treatment

Leachate collected in the active landfill cell is pumped from the leachate sump through a leachate riser (a large diameter riser pipe containing a pump) and routed to the leachate treatment system, which comprises a leachate plain and a series of sedimentation ponds.

The leachate plain is a gently sloping and irrigated reed bed populated with Monto Vetiver *Chrysopogon zizanioides*. Leachate from the landfill passes through the leachate plain, where the reeds absorb water, nutrients and pollutants such as heavy metals.

The treated water is then collected in a series of sedimentation ponds downstream of the leachate plain to allow retention time for solids separation. Treated water is discharged from the final sedimentation pond to the environment. In case the treated water does not meet the discharge requirements shown in Table 9-4, it can be recycled through the leachate plain and sedimentation ponds.

12.7 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 HWMF or HGCP, or transfer to third party facilities for reuse, recycling and/or recovery.

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.

Upon receipt of the wastes at the HWMF or HGCP, the wastes will be inspected and the waste manifest verified as part of the waste acceptance process. The waste manifest will be

completed and closed with details of the immediate fate of the wastes (for example immediate incineration, transfer to storage, transfer to liquid injection pump station, or transfer to landfill).

A waste incineration record is maintained for all incinerator burn cycles to track the type and quantity of incinerated wastes (both at the HWMF or HGCP). A landfill acceptance record is maintained to track the type and quantity of all wastes disposed of to landfill.

Waste transferred from the HWMF to third party facilities for reuse, recycling and/or recovery will be accompanied by a waste transfer record which identifies the type and quantity of wastes and provides 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.

12.8 Waste monitoring

EHL will undertake periodic inspections of the waste management process from point of generation and collection, through storage, treatment and final disposal. Inspections are discussed further in Section 20.0.

12.9 Export of restricted waste

EHL 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 (Secretariat of the Basel Convention, 1992)* 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 (Secretariat Pacific Regional Programme, 2001)* will be applied.

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

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

WASTE TYPE	WASTE DESCRIPTION	TREATMENT	DISPOSAL
Solid (non-restricted)	Drill cuttings	Dewater	Landfill
	Drums (plastic)	Clean, crush, shred, incinerate	Incinerator ash to landfill
	Drums (metal)	Clean, crush, shred	Landfill
	Barrels/containers	Clean, crush	Landfill
	Tyres	Debead, shred, incinerate	Incinerator ash to landfill
	Metals (equipment/parts/offcuts)	Shred	Landfill
	Rubber	Shred, incinerate	Landfill
	Timber	Shred, incinerate	Incinerator ash to landfill
	Putrescible	Incinerate	Incinerator ash to landfill
	Construction and demolition debris	N/A	Landfill
	Plastic packaging and scrap	Incinerate	Incinerator ash to landfill
	Electrical goods	Shred, incinerate	Incinerator ash to landfill
Liquid (non-restricted)	Landfill leachate	N/A	Water treatment plant
	Sewage	N/A	Water treatment plant
	Tank and vessel bottom waste	N/A	Water treatment plant
	Concrete washings	N/A	Landfill
	Antifreeze	N/A	Water treatment plant
	Fire fighting foam	N/A	Landfill
Restricted	Incinerator ash (HWMF units)	Stabilise	Landfill
	Batteries	Recycle or stabilise	Landfill (where stabilised)
	Solvents	Recycle/incinerate	Incinerator ash to landfill
	Sewage sludge	Dewater, incinerate	Incinerator ash to landfill
	Contaminated soil and absorbent	Incinerate	Incinerator ash to landfill
	Aerosol canisters	Crush	Landfill

WASTE TYPE	WASTE DESCRIPTION	TREATMENT	DISPOSAL
	Oils and greases	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)	Incinerate	Incinerator ash to landfill
	Paint (water-based)	Dewater, incinerate	Incinerator ash to landfill
	Chemical solids	Stabilise	Landfill
	Medical (clinic) waste	Incinerate	Incinerator ash to landfill
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.			

13.0 EROSION AND SEDIMENT CONTROL

EHL'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 below.

13.1 Inspection

EHL will conduct inspections within and in the immediate vicinity of the Upstream Facilities, Infrastructure and Pipelines. 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.

Inspections undertaken by EHL may be supplemented by monitoring undertaken by a landowner/community service provider.

13.2 Maintenance and remedial action

Where deemed necessary, for example to protect asset integrity and/or prevent sedimentation of surface waters, EHL will respond to erosion, slope stability and/or sedimentation issues.

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 EHL may be supplemented by controls undertaken by the service provider, under direction from EHL.

13.3 New disturbance

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

- Avoidance of stockpiling spoil and/or topsoil materials close to surface waters (maintain a minimum of 10 metres from waterline)
- Installation of erosion control structures to prevent subsidence
- Installation and maintenance of sediment control structures to prevent sedimentation of surface waters
- Monitoring of erosion and sediment control structures until adequate stabilisation has been achieved
- Control of potential scouring at culverts through drainage and energy dissipation devices, such as rock mattresses or gabions

14.0 REINSTATEMENT AND REGENERATION

EHL'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 and land in the immediate vicinity of permanent facilities and infrastructure 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 below.

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. Due to customary land title prevalent in Papua New Guinea, EHL cannot prohibit access by landowners. Access will be discouraged and EHL will maintain statutory payments to the landowning communities for deprivation of use as a means to reduce encroachment on regenerating areas.

14.2 Inspection

EHL will conduct inspections of regenerating areas to observe status of regeneration and check for evidence of encroachment on regenerating areas.

Where encroachment is identified, EHL 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 EHL's ability to control.

14.3 Regeneration monitoring

The inspection process is supplemented by regeneration monitoring, which is based on surveys of regenerating areas to collect and analyse data relating to the succession of vegetation and condition of forest. The overall objective of the regeneration monitoring program is to evaluate regeneration performance.

The regeneration monitoring program uses fixed and random sampling and a benchmarking scoring system to evaluate the progression of plant community succession. Further details about the regeneration monitoring program are provided in Appendix 3.

14.4 Maintenance and remedial action

EHL 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 EHL'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 EHL's ability to control outcomes, for example where landowners insist on access to a regenerating area. In these situations, EHL will engage with the relevant party/parties and endeavour to achieve desired outcomes.

14.5 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
- Use of soil, mulch and vegetation to facilitate natural regeneration
- Decompaction 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
- Installation of diversion drains, berms, slope breakers and other controls to reduce erosion and subsidence
- 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
- Monitoring and maintenance of erosion control structures until adequate slope stabilisation, sediment control and subsidence control has been achieved

15.0 INVASIVE SPECIES, PESTS AND PLANT PATHOGENS

EHL's objectives are to prevent priority invasive species, pests and plant pathogens from entering or becoming established in or in the vicinity of EHL's facilities and infrastructure; and contain existing priority invasive species, pests and plant pathogens already present.

Measures to prevent, mitigate or otherwise control potential environmental impacts associated with weeds, pests and plant pathogens are described in this section.

15.1 Invasive species: identification

Invasive species 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	Invasive of a natural ecosystem; ability to rapidly colonise bare ground.
Priority 2	Persistent in the natural ecosystem; ability to become locally dominant.
Priority 3	Persistent in the natural ecosystem only where there is ongoing disturbance.

Details of all invasive species identified in EHL'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 invasive species, including photographs and appropriate control measures, are included in an invasive species identification manual.

15.2 Invasive species: management and monitoring

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

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

There is a notable reduction of documented invasive species from a certain altitude upwards (KP 3.5) on the Hides Ridge. To prevent the ingress of invasive species beyond KP 3.5, all vehicles will be washed at the HVWF and issued with a wash certificate.

EHL will conduct inspections within and in the immediate vicinity of the Upstream Facilities, Infrastructure and Pipelines. The presence of invasive species will be checked as part of the inspections in accordance with the priorities established in the invasive species management zones. Inspections will focus on the potential occurrence of previously unrecorded species and the potential expansion or increase in abundance.

Inspections undertaken by EHL may be supplemented by monitoring undertaken by a landowner/community service provider.

Table 15-2: Invasive species management zones

ZONE	ECOLOGICAL UNIT	EXISTING PRIORITY 1 SPECIES	OBJECTIVES
Hides Ridge	Montane forest (1,800-2,850 metres above sea level)	Elephant Grass *Cenchrus purpureum*	Exclude Priority 1 and Priority 2 species. Develop HGCP to Hides Ridge KP 3.5 (clean/dirty line) as a quarantine zone.
		Frangipani Ginger *Hedychium coronarium*	
		Japanese Sunflower *Tithonia diversifolia*	
		Coffee *Coffea arabica*	
		Silver-leaf Desmodium *Desmodium uncinatum*	
		Spiked Pepper *Piper aduncum*	
Angore	Montane forest	Elephant Grass *Cenchrus purpureum*	Control Priority 1 species.
		Frangipani Ginger *Hedychium coronarium*	
		Japanese Sunflower *Tithonia diversifolia*	
		Coffee *Coffea arabica*	
		Silver-leaf Desmodium *Desmodium uncinatum*	
		Spiked Pepper *Piper aduncum*	
		Giant Cane *Arundo donax*	
		Spanish Tickfoil *Desmodium repandum*	
		Wandering Jew *Tradescantia zebrine*	
HGCP-Komo	Montane forest (900-1,700 metres above sea level)	Elephant Grass *Cenchrus purpureum*	Control Priority 1 species.
		Frangipani Ginger *Hedychium coronarium*	
		Japanese Sunflower *Tithonia diversifolia*	
		Coffee *Coffea arabica*	
		Silver-leaf Desmodium *Desmodium uncinatum*	
		Spiked Pepper *Piper aduncum*	
		Giant Cane *Arundo donax*	
		Orange Desmodium *Desmodium repandum*	
		Lantana *Lantana camara*	

ZONE	ECOLOGICAL UNIT	EXISTING PRIORITY 1 SPECIES	OBJECTIVES
		Guava *Psidium guava*	
		Glycine *Neonotonia wightii*	
		Singapore Daisy *Sphagneticola trilobata*	
HGCP-Lake Kutubu (including HGCP and Hides landfill sites)	Montane forest (900-1,700 metres above sea level)	Elephant Grass *Cenchrus purpureum*	Control Priority 1 species.
		Frangipani Ginger *Hedychium coronarium*	
		Japanese Sunflower *Tithonia diversifolia*	
		Coffee *Coffea arabica*	
		Silver-leaf Desmodium *Desmodium uncinatum*	
		Spiked Pepper *Piper aduncum*	
		Giant Cane *Arundo donax*	
		Molasses Grass *Melinis minutiflora*	
		Kudzu *Pueraria phaseoloides*	
		Woolly Senna *Senna hirsuta*	
		Hairy Crotalaria *Crotalaria incana ssp Purpurascens*	
		Lantana *Lantana camara*	
		Guava *Psidium guava*	
		Candle-stick Senna *Senna alata*	
		Hairy Senna *Senna hirsute*	
		Sedge *Cyperus distans*	
		Orange Desmodium *Desmodium repandum*	
		Wandering Jew *Tradescantia zebrina*	
		Para Grass *Urochloa mutica*	
		Glycine *Neonotonia wightii*	
Homa-Benaria	Montane forest (1,800-2,850 metres above sea level)	Silver-leaf Desmodium *Desmodium uncinatum*	Exclude all Priority 1 and Priority 2 species.

ZONE	ECOLOGICAL UNIT	EXISTING PRIORITY 1 SPECIES	OBJECTIVES
Lake Kutubu (Moro)	Wetlands/swamp forest (900 metres above sea level)	Elephant Grass *Cenchrus purpureum*	Control Priority 1 species.
		Frangipani Ginger *Hedychium coronarium*	
		Coffee (*Coffea arabica*	
		Silver-leaf Desmodium *Desmodium uncinatum*	
		Spiked Pepper *Piper aduncum*	
		Japanese Sunflower *Tithonia diversifolia*	
Lake Kutubu-Mubi River	Upland forest (70-900 metres above sea level)	Bitter Vine *Mikania micrantha*	Control Priority 1 species. Exclude all Priority 1 and Priority 2 species from roadsides between Mubi River and Kantobo.
		Silver-leaf Desmodium *Desmodium uncinatum*	
		Spiked Pepper *Piper aduncum*	
		Kudzu *Pueraria phaseoloides*	
Mubi River- Kikori River	Lowland forest (25-70 metres above sea level)	Bitter Vine *Mikania micrantha*	Control Priority 1 species. Manage zone as a quarantine buffer between lowland and upland/highland sections.
		Spiked Pepper *Piper aduncum*	
		Kudzu *Pueraria phaseoloides*	
Kikori River-Omati	Lowland forest/swamp forest (0-25 metres above sea level)	Lantana *Lantana camara*	Control existing Priority 1 species and prevent the introduction of new Priority 1 species.
		Guava *Psidium guava*	
		Anglestem Willow Primrose *Ludwigia leptocarpa*	
		Bitter Vine *Mikania micrantha*	
		Para Grass *Urochloa mutica*	

15.3 Invasive species: remedial action

Where intervention is required in accordance with the priorities established in the invasive species management zones, EHL will implement invasive species controls, which may include physical removal, slashing (cut stump), mulching and/or and application of herbicides as appropriate.

Controls implemented by EHL may be supplemented by controls undertaken by a landowner/community service provider, under direction from EHL.

The occurrence, distribution and trends of invasive species in the area of EHL'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 Plant pathogens: identification

The only known plant pathogen of relevance in EHL's area of operations is *Phytophthora cinnamomi,* which is best described as an algae. There are known to be two different types of *Phytophthora cinnamomi* in Papua New Guinea, referred to as type A1 and type A2, although research suggests that they may be different species.

Type A1 is thought to have occurred in Papua New Guinea for tens of thousands of years and is usually associated with remote undisturbed areas (although it also occurs in disturbed areas), whereas type A2 is only associated with anthropogenic disturbance and the cultivation of exotic plants.

Both types appear to be associated with tree senescence (tree death or dieback). It is thought that the type A1 association with senescence, if any, is only a function of tree health and environmental factors which may predispose a tree to infection. In the case of type A2, it is thought that native trees in Papua New Guinea have not yet developed a natural defence to the fungus due to its relatively recent occurrence and hence it is likely to cause senescence.

Current scientific thinking was upheld by the results of surveys and studies undertaken by EHL during construction. Type A1 *Phytophthora cinnamomi* was identified in many locations throughout the Upstream Project Area, including relatively undisturbed locations such as Hides Ridge, and no association with senescence was observed. Type A2 *Phytophthora cinnamomi* was found only at certain locations and associated with exotic plant species under cultivation or forests subject to anthropogenic disturbance and senescence was observed in its proximity.

15.5 Plant pathogens: management and monitoring

Phytophthora cinnamomi can be spread by the movement of soil containing the pathogen.

Based upon current scientific research, coupled with recommendations from an independent expert advisor, EHL manages *Phytophthora cinnamomi* by preventing the spread or introduction of Type A2 into unaffected areas, in particular ecologically sensitive areas which are susceptible to senescence.

Of particular relevance to this EMP is the high altitude forest on Hides Ridge which comprises Papua New Guinea Oak *Castanopsis acuminatissima* and Antarctic Beech *Nothofagus rubra*, *Nothofagus pullei* and *Nothofagus grandis*, both of which are vulnerable to infection by *Phytophthora cinnamomi* and senescence.

While senescence of Papua New Guinea Oak and Antarctic Beech may not be associated with Type A2 *Phytophthora cinnamomi*, EHL applies the precautionary principle in this regard. To prevent the ingress of *Phytophthora cinnamomi* to the Hides Ridge, all vehicles are washed at the HVWF and issued with a wash certificate.

EHL will conduct ground and aerial inspections within and in the immediate vicinity of the Upstream Facilities, Infrastructure and Pipelines. The health of forests and evidence of senescence will be checked as part of the inspections. Videography will be used where appropriate.

Inspections undertaken by EHL may be supplemented by monitoring undertaken by a landowner/community service provider.

15.6 Plant pathogens: remedial action

Based on the results of inspections, sampling may be required to determine the cause of the observed senescence and the occurrence of *Phytophthora cinnamomi*. Where *Phytophthora cinnamomi* is confirmed as the cause, EHL will consult with an independent expert advisor to determine appropriate mitigation measures.

Remedial action may be readily achievable and within EHL's control, for example soil hygiene measures to prevent movement of Type A2 *Phytophthora cinnamomi.* In such cases controls will be implemented by EHL, where necessary supported by specialist third parties and/or a landowner/community service provider.

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

15.7 New disturbance

Where operations and/or maintenance 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 occurrence of invasive species, pests, and the occurrence of senescence and *Phytophthora cinnamomi* will be determined. Site-specific hygiene and other mitigation measures will be developed.

15.8 Quarantine

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

While responsibility for quarantine control rests with the Papua New Guinean National Agriculture Quarantine and Inspection Authority, EHL'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 EHL are required to inspect cargo, containers and break-bulk cargo at the point of origin and 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.

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

Quarantine hygiene measures will be applied as necessary at the Komo Airfield (upon arrival of international flights).

Quarantine requirements are further described in the Quarantine Procedure.

16.0 ECOLOGY

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

Disturbance and/or harassment of wildlife, hunting of fauna, gathering of plants or bush foods, collection of firewood or possession of wildlife products is prohibited.

Focal habitats and other ecological sensitivities within and in the immediate vicinity of the Upstream Facilities, Infrastructure and Pipelines 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 focal habitats and sensitive ecological features in the vicinity of the Upstream Facilities, Infrastructure and Pipelines and prevent impacts to these features are described in this section.

It should be noted that direct impacts to focal habitats and sensitive ecological features during normal operations are expected to be negligible. In addition to avoiding new impacts to features of ecological importance, the focus of ecological management during operations is therefore monitoring for potential residual impacts from the construction phase, which may evolve or manifest during production.

16.1 Inspection

Details of focal habitats and other ecological sensitivities in the vicinity of the Upstream Facilities, Infrastructure and Pipelines are included in a register.

EHL will conduct inspections within and in the immediate vicinity of the Upstream Facilities, Infrastructure and Pipelines. The condition of focal habitats and other sensitive ecological features will be checked as part of the inspections.

Inspection of focal habitats and sensitive ecological features forms part of EHL's Biodiversity Monitoring Plan, which sets out the process which EHL will follow to monitor and evaluate the extent to which the objectives of EHL's Biodiversity Strategy, available at www.pnglng.com) are being achieved and the significance of any change to the condition of the ecological sensitivity determined.

16.2 Remedial action

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

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

16.3 New disturbance

Where operations and/or maintenance activities involve new or additional disturbance of land (beyond the construction footprint), previously disturbed areas will be selected preferentially in order to avoid disturbance of old growth forest. In all cases, a pre-disturbance survey of the area to be affected will be undertaken. As part of the pre-disturbance survey, the existence of focal habitats or other potentially sensitive ecological features (including those identified in the Environment Permit) will be determined. Site-specific mitigation and management measures will be adopted to avoid and/or otherwise mitigate potential impacts to identified features (including caves providing habitat for bat colonies, lecking trees for Birds-of-Paradise or Bowerbirds, *Pandanus* swamp forest, *Northofagus* forest, and other sites or habitats of ecological significance) and species of conservation concern.

Mitigation measures will include, as appropriate:

- Retain large trees when they are situated along worksite borders or where work can be undertaken around these trees
- Prohibit hunting, gathering of plants or bush foods, collection of firewood or possession of wildlife products by EHL staff or contractors
- Avoid display grounds of Birds-of-Paradise and Bowerbird where possible
- Maintain adequate surface flows and avoiding redirection of stream flows where practical
- Avoid unnecessary access to caves with bat colonies
- Where practicable, avoid sidecasting onto landslides and into open valleys, headwaters, waterways and sinkhole swamps on Hides Ridge
- Mitigating impacts from sidecasting in steep terrain areas, for example implementing sediment control measures downstream of sidecast material where practical

17.0 ACCESS

EHL's objectives are to control vehicle access to Project roads and infrastructure to prevent potentially damaging third party activities through enhanced access.

In most cases, roads and infrastructure put in place during the construction phase were temporary in nature and were removed, reinstated and/or made impassable at the end of construction. Details regarding the nature, location and fate of each temporary access road and infrastructure are included in a register.

In some cases sections of road and other infrastructure are required during production and remain in place. This section sets out measures to control vehicle access to permanent roads and infrastructure, as relevant to the scope of this EMP.

Table 17-1 lists the access in place during production to AGIs, the gas and condensate pipeline RoW and other roads and infrastructure. A description of each access is provided and the access controls are defined.

Access will generally be allowed only to EHL vehicles. Access by third party vehicles serving operational needs may be sanctioned subject to prior approval from EHL. Access by landowner vehicles may be sanctioned subject to prior approval from EHL. In both cases, access will be authorised only by designated EHL personnel. Vehicles will be inspected as deemed appropriate.

EHL will conduct inspections of the access controls described in Table 17-1. Where breach of access control is identified, EHL will engage with the relevant party/parties and endeavour to achieve access control. It should be recognised that a remedy may not be readily achievable and beyond EHL's ability to control.

Additional access points beyond those identified in Table 17-1 may be required and where this is the case appropriate controls will be adopted to prevent potentially damaging third party activities.

Table 17-1: Access and access controls

FACILITY/INFRASTRUCTURE	ACCESS DESCRIPTION	ACCESS CONTROL
Hides Gathering System and Spineline	Access to the Hides Gathering System and Spineline is achieved via the HWPAR.	Vehicle access to the HWPAR is controlled via a manned gate at the HVWF.
Angore Gathering System and Spineline	Access to the Angore Gathering System and Spineline is achieved via the AWPAR.	Vehicle access to the AWPAR is controlled via a manned gate.
Condensate Pipeline Check Valve 1	CV1 is located on the combined gas/condensate pipeline RoW at KP 7.2, in the vicinity of Tagari and within approximately 1 kilometre of an existing public road (Tagari River Roads). Vehicle access to CV1 is achieved from the public road and subsequently using a 500-metre section of pipeline construction track that is maintained operational.	Vehicle access to CV1 is controlled via an unmanned gate located at the junction between the public road and the pipeline construction track.
Condensate Pipeline MLV1	MLV1 is located on the combined gas/condensate pipeline RoW at KP 27.5, in the vicinity of Benaria and within approximately 2 kilometres of an existing public road (Benaria Station Road). Vehicle access to MLV1 is achieved from the public road at KP26 and subsequently via a 1.5-kilometre section of pipeline construction track, which is maintained operational.	Vehicle access to MLV1 is controlled via an unmanned gate at the junction between the public road and the pipeline construction track.
Condensate Pipeline MLV2	MLV2 is located on the combined gas/condensate pipeline RoW at KP 53, in the vicinity of Homa. MLV2 is served via helicopter and there is no vehicle access.	N/A
Condensate Pipeline MLV3	MLV3 is located on the combined gas/condensate pipeline RoW at KP 66.5, in the vicinity of Paua and within 1 kilometre of an existing public road (Homa-Moro Road). Vehicle access to MLV3 is achieved from the public road at KP 67 and then via a 500-metre section of pipeline construction track that is maintained operational.	Vehicle access to MLV3 is controlled via an unmanned gate located at the junction between the public road and the pipeline construction track.
Condensate Pipeline MLV4 (and Gas Pipeline RoW KP 81.5 Access)	MLV4 is located on the combined gas/condensate pipeline RoW at KP 85, in the vicinity of Lake Kutubu. Vehicle access to MLV4 is achieved from an existing public road (Homa-Moro Road), firstly via a 1 kilometre section of pipeline access track which links the public road with the RoW at KP 81.5 and then via a 5-kilometre section of pipeline construction track, which is maintained operational between KP 81.5 and MLV4.	Vehicle access to MLV4 is controlled via an unmanned gate located at the junction between the public road and the pipeline access track.
Condensate Pipeline Check Valve 2	CV2 is located on the combined gas/condensate pipeline RoW at KP 95, in the vicinity of Moro, where the RoW runs adjacent to an existing OSL controlled access road. Vehicle access to CV2 is achieved directly from the road.	N/A

FACILITY/INFRASTRUCTURE	ACCESS DESCRIPTION	ACCESS CONTROL
Gas Pipeline Kutubu MLV	Kutubu MLV is located on the gas pipeline RoW at KP 107.5, within approximately 3.5 kilometres of an existing OSL controlled access road. Vehicle access to the Kutubu MLV is achieved from the road and subsequently via a 3.5 kilometre section of pipeline construction track that is maintained operational.	Vehicle access to Kutubu MLV is controlled via an unmanned gate between the road and the pipeline construction track.
Gas Pipeline Cathodic Protection Station 1	CP1 is located on the gas pipeline RoW at KP 153, on a section where the RoW runs adjacent to an existing OSL controlled access road (Kutubu-Kantobo Road). Vehicle access to CP1 is achieved directly from the road.	N/A
Gas Pipeline Gobe MLV	Gobe MLV is located on the gas pipeline RoW at KP 192, in the vicinity of Gobe, within approximately 1 kilometre of an existing OSL controlled access road (Gobe-Kopi Road). Vehicle access to the MLV is achieved from the road and subsequently via a 1-kilometre section of pipeline construction track that is maintained operational.	Vehicle access to Gobe MLV is controlled via an unmanned gate at the junction between the road and the pipeline construction track.
Gas Pipeline Cathodic Protection Station 2	CP2 is located on the gas pipeline RoW at KP 227, just to the south of the Kikori River, within 1 kilometre of an existing public access track. Vehicle access to CP2 is achieved from the public access track and subsequently via a 1-kilometre section of pipeline construction track that is maintained operational.	Vehicle access to CP2 is controlled via an unmanned gate at the junction between the public access track and the pipeline construction track.
Gas Pipeline Kopi Scraper Station	Kopi Scraper Station is located on the gas pipeline RoW at KP 266 in the vicinity of Kopi, at the intersection between the RoW and an existing public road leading to Kopi Shore Base. Vehicle access to Kopi Scraper Station is achieved directly from the public road.	Vehicle access to Kopi Scraper Station is controlled via an unmanned gate at Kopi Shore Base.
Gas Pipeline RoW KP 101.8 Access	A pipeline access track of approximately 0.3 kilometres was installed during construction between the OSL controlled road near Agogo and the combined gas/condensate pipeline RoW at KP 101.8. This track has been retained for operational access to the pipeline RoW and the future Agogo tie-in and above ground valves.	Access is controlled via an unmanned gate at the junction between the pipeline access track and the OSL road.
Gas Pipeline RoW KP 232 Access	A pipeline access track of approximately 1 kilometre was installed during construction between an existing public road (Kopi to Kaiam Road) and the gas pipeline RoW at KP 232. This track has been retained for access to the pipeline RoW during production.	Access is controlled via an unmanned gate at the junction between the pipeline access track and the public road.
Gas Pipeline RoW KP 236 Access	A pipeline access track of approximately 0.5 kilometres was installed during construction between an existing logging track and the gas pipeline RoW at KP 236. This track has been retained for access to the pipeline RoW during production.	Access is controlled via an unmanned gate at the junction between the pipeline access track and the logging track.

FACILITY/INFRASTRUCTURE	ACCESS DESCRIPTION	ACCESS CONTROL
Gas Pipeline RoW KP 239 Access	A pipeline access track of approximately 0.25 kilometres was installed during construction between an existing logging track and the gas pipeline RoW at KP 239. This track has been retained for access to the pipeline RoW during production.	Access is controlled via an unmanned gate at the junction between the pipeline access track and the logging track.
Gas Pipeline RoW KP 242 Access	A pipeline access track of approximately 0.25 kilometres was installed during construction between an existing logging track and the gas pipeline RoW at KP 242. This track has been retained for access to the pipeline RoW during production.	Access is controlled via an unmanned gate at the junction between the pipeline access track and the logging track.
Kantobo-Mubi River Road and Mubi River Bridge	A new road was installed during construction between Kantobo and Mubi River as part of the southern logistics route serving pipeline construction. The Kantobo-Mubi River Road is approximately 11.4 kilometres. A new bridge was also installed over the Mubi River. Both will remain in place during production.	Access to the Kantobo-Mubi River Road and Mubi River Bridge is controlled from the north via an unmanned gate located at the northern end of the road close to its junction with the RoW at KP 164. Access from the south is controlled at Gobe, as discussed below.
Mubi River to Gobe Road	An existing road between Mubi River and Gobe was upgraded during construction as part of the southern logistics route serving pipeline construction. The Mubi River-Gobe Road is approximately 18 kilometres. The road runs directly adjacent to the OSL operated oil pipeline and, generally, to the gas pipeline and will remain in place during production.	Access to the Mubi River-Gobe Road is controlled from the south via manned gates located close to Gobe.
Kikori River Bridge	A new bridge was installed during construction over the Kikori River as part of the southern logistics route serving pipeline construction. The Kikori River Bridge remains in place during production.	Access to the Kikori River Bridge is controlled via a manned gate.

18.0 CULTURAL HERITAGE

EHL'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 Upstream Facilities, Infrastructure and Pipelines were identified as part of the EIS and the environmental pre-construction survey program during construction. Site-specific mitigation and management measures were adopted to avoid and otherwise mitigate potential impacts.

Measures to monitor the condition of cultural heritage sensitivities in the vicinity of the Upstream Facilities, Infrastructure and Pipelines 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.

18.1 Inspection

Details of cultural heritage sensitivities in the vicinity of the Upstream Facilities, Infrastructure and Pipelines are included in a register.

EHL will conduct inspections within and in the immediate vicinity of the Upstream Facilities, Infrastructure and Pipelines. The condition of cultural heritage sensitivities will be checked as part of the inspections.

18.2 Remedial action

Based on the results of inspections, and where problems are noted, EHL 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 EHL's control, it will be undertaken by qualified archaeologists supported by EHL as needed.

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

18.3 New disturbance

Where operations and/or maintenance 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. 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 mitigations listed below 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, EHL 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, EHL 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, access thereto 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, EHL will consult with landowners or clan representatives to agree the appropriate mitigation measures (for example spirit moving ceremony or compensation). 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, access thereto 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, EHL 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 site-specific measures discussed above, EHL 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.

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 protocol is documented in the Archaeological Salvage Procedure.

18.4 Management of salvaged archaeological material

Archaeological salvage undertaken during construction was completed in accordance with the terms of the Permit for Salvage Archaeology (Upstream) issued by National Museum and Art Gallery on 30 September 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 Hides Gas Conditioning Plant (Monash University, 2013)* 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 Salvage Archaeology and the *National Cultural Property (Preservation) Act 1965.*

19.0 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 20.0.

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.

19.1 Monitoring of emissions to air

Monitoring of emissions to air from relevant emissions sources at the HGCP and the HWMF is outlined in Table 19-1.

Table 19-1: Monitoring of emissions to air

FACILITY	PARAMETER	EMISSION GUIDELINE VALUE	SUMMARY	FREQUENCY**
HGCP compressor gas turbines	Oxides of nitrogen	25 ppm	Stack test	Annual
HGCP main power generators	Oxides of nitrogen	42 ppm	Stack test	Annual
HGCP MEGVG incinerator	BTEX	N/A	Stack test	Annual
HGCP industrial area incinerator HWMF incinerator	PM	70 mg/m^3	Stack test	Annual
	Carbon monoxide	157 ppm		
	Oxides of nitrogen	388 ppm	Stack test	Annual
	Oxides of sulphur	20 ppm	Stack test	Annual
	Hydrogen chloride	62 ppm	Stack test	Annual
	Cadmium	0.004 mg/m^3	Stack test	Annual
	Lead	0.04 mg/m^3	Stack test	Annual
	Mercury	0.47 mg/m^3	Stack test	Annual
	Dioxin/furan	0.41 ng/m^3	Stack test	Annual
	Opacity	10 percent	Visual observation	Daily

Source (compressor gas turbines and main power generators): *General Environmental, Health and Safety (EHS) Guidelines (IFC, 2007)*, Table 1.1.2 - Small Combustion Facilities Emissions Guidelines.

Source (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)*.

Emission guideline values apply during normal steady state operations, and not start-up, shut-down and abnormal operations.

Compressor gas turbines 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.

**Monitoring will be undertaken twice yearly for the first two years of operations and annually thereafter.

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

19.2 Monitoring of ambient air quality

Monitoring of ambient air quality will be undertaken periodically in the vicinity of the HGCP and the HWMF 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 will be undertaken at the HGCP once the facility has achieved steady state operations, but in any case within the first two years of production. Ambient air quality monitoring will then be undertaken at regular intervals. Frequency of ambient air quality monitoring will be determined on the basis of need and environmental risk but in any event will be undertaken no less than every five years. Ambient air quality monitoring will be conducted on behalf of EHL by a competent specialist in accordance with standard industry methods. The focus of ambient air quality monitoring will be sensitive community receptors within the vicinity of the HGCP and the HWMF, as identified as part of baseline air quality assessments and dispersion modelling exercises.

19.3 Monitoring of noise

Monitoring of noise will be undertaken periodically at perimeter fence lines and sensitive receptors in the vicinity of the Upstream Facilities, Infrastructure and Pipelines to validate data obtained through noise modelling and evaluate conformance with the guideline values in Table 8-1. Noise monitoring will be undertaken in accordance with the method set out in the Noise Monitoring Procedure.

19.4 Monitoring of water abstraction

The volume of water abstracted from each surface water and groundwater abstraction point 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).

19.5 Monitoring of discharges to water

Monitoring of stormwater discharges from the Hides Wellpads, Angore Wellpads, HGCP, HWMF and HVWF consists of periodic 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 to water from relevant process sources at the HGCP and the HWMF 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 to water from WWTP treating sewage at the HGCP and the HWMF consists of periodic in-situ sampling of the parameters shown in Table 9-8. Monitoring will be undertaken in accordance with the method set out in the WWTP Effluent Monitoring Procedure.

Monitoring of leachate discharges from the landfill at the HWMF consists of periodic grab samples of the parameters shown in Table 9-4. Monitoring will be undertaken in accordance with the method set out in the Leachate Monitoring Procedure.

The criteria referenced in the above tables are considered applicable based on EHLs understanding of the discharge types and their respective constituents. In order to determine those parameters relevant to the discharges, EHL will undertake initial monitoring campaigns during the first two years of production which cover 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 (process wastewater), Table 9-8 (WWTPs) and Table 9-4 (leachate) are deemed by EHL 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*.

19.6 Monitoring of surface water quality

Monitoring of surface water quality will be undertaken at select locations representative of potential effects resulting from HGCP discharges. This monitoring will be undertaken twice during the first two years of production (campaigns may be contiguous) and every five years thereafter. Parameters to be monitored are shown in Table 9-4. Monitoring will be undertaken in accordance with the method set out in the Surface Water Quality Monitoring Procedure.

19.7 Monitoring of groundwater quality

Monitoring of groundwater quality in the vicinity of the landfill at the HWMF consists of periodic grab samples of the parameters shown in Table 19-2. Samples will be taken at one up-gradient well, two cross-gradient wells and two down-gradient wells in accordance with the method set out in the Groundwater Monitoring Procedure.

Table 19-2: Monitoring of groundwater

PARAMETER	GUIDELINE VALUE	SUMMARY	METHOD
pH	No alteration above background.	Grab sample at one up-gradient well, two cross-gradient wells and two down-gradient wells. Conducted every six months.	See Groundwater Monitoring Procedure.
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			

PARAMETER	GUIDELINE VALUE	SUMMARY	METHOD
Faecal coliforms			
Phenols			
Source: Annex 2 of EHL's Environment Permit, based on *Environment (Water Quality Criteria) Regulation 2002,* Water Quality Criteria for Aquatic Life Protection.			

19.8 Monitoring of surface water ecology

Monitoring of ecological conditions will be undertaken at select locations representative of potential effects resulting from HGCP discharges. This monitoring will be undertaken twice during the first two years of production (campaigns may be contiguous) and every five years thereafter. Monitoring will be undertaken in accordance with the method set out in the Surface Water Ecology Monitoring Procedure.

19.9 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).

20.0 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 and Commitment, OIMS System 6-5 Environmental Management and OIMS System 11-1 OIMS Assessments.

20.1 Verification and inspection

EHL 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 EHL in accordance with a predetermined protocol 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 protocol for the field-based verification and inspection 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 20-1.

20.2 Assessment

EHL 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. OIMS assessments will be undertaken in accordance with OIMS System 11-1 OIMS Assessments, to evaluate the degree to which OIMS requirements are met as part of the implementation of this EMP.

In addition to periodic assessments, EHL will 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 EHL waste are subject to prior assessment and approval. EHL may undertake assessments of other third party facilities and providers, as relevant to this EMP.

Assessments undertaken by EHL will be documented in a register including details of the assessments and a summary of the findings and results.

Table 20-1: Verification and inspection

ASPECT/CONTROL	GENERAL SCOPE OF VERIFICATION/INSPECTION
Emissions to air	• Visual inspection of stack and flare emissions • 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 • Direction of perimeter and other lighting
Ambient air quality	• Ambient air quality monitoring results

ASPECT/CONTROL	GENERAL SCOPE OF VERIFICATION/INSPECTION
Noise	• Noise monitoring results • Notification to affected communities of high intensity noise events
Discharges to water	• Visual inspection of stormwater systems and discharge locations • Visual inspection of open drain systems and discharge locations • Visual inspection of WWTP discharges • Visual inspection of leachate treatment system and discharges • WWTP operating conditions • Discharge monitoring results
Spill prevention and response	• Third party transport of fuel and chemicals • 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 part supply of timber
Waste	• Registers • Waste avoidance and minimisation • Waste collection areas and process • Waste storage areas and process • Waste reuse, recycling and recovery • Waste transfer to third parties • Waste treatment areas and process • Waste incineration area and process • Ash stabilisation area and process • Landfill area and process • Leachate treatment area and process • Waste tracking documentation
Erosion and sediment	• Condition of erosion control works • Condition of surface waters • Mitigations for new disturbance
Reinstatement and regeneration	• Condition of reinstatement works/devices • Status of reinstatement and regeneration • Encroachment of regenerating areas • Mitigation for new disturbance
Invasive species, pests and plant pathogens	• Registers • Invasive species identification manual • Presence of new invasive species and pests • Increase in abundance and distribution of existing invasive species and pests • Condition of forest • Evidence of tree senescence
Ecology	• Register of focal habitats and ecological sensitivities • Condition of focal habitats and ecological sensitivities • Mitigation for new disturbance

ASPECT/CONTROL	GENERAL SCOPE OF VERIFICATION/INSPECTION
Access	• Registers • Encroachment on regenerating areas • Access controls • Encroachment
Cultural heritage	• Registers • Condition of cultural heritage sensitivities • Mitigation for new disturbance

20.3 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 audits of the environmental aspects controls set out in this EMP.

The DEC may undertake environmental audits of the environmental aspects controls set out in this EMP.

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

20.4 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.

20.5 Performance indicators

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

Performance indicators relevant to this EMP are shown in Table 20-2, including relevant indicators from the Environmental Performance Indicators Manual.

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

Table 20-2: 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.	Exceedance of emissions criteria.	Number
	Meet applicable emissions and air quality criteria.	Exceedance of air quality criteria.	Number
Noise	Avoid significant noise and vibration impacts to community and fauna.	Noise-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.	Exceedance of discharge criteria.	Number
	Meet applicable discharge criteria.		
Spill prevention and response	Prevent spills of hydrocarbons and chemicals.	Release of hydrocarbons and/or chemicals to the environment.	Type and number
	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
	Use materials that are less hazardous or otherwise preferable from an environmental perspective, where practical.		
Waste	Apply the waste management hierarchy.	Waste managed and disposed of at EHL facilities and approved/licensed third party facilities only.	Percent
	Manage and dispose of waste at EHL facilities and approved/licensed third party facilities only.		
Erosion and sediment	Control significant erosion and prevent sedimentation of surface waters.	Occurrence of significant erosion.	Number
		Sedimentation of surface waters.	Number
Reinstatement and regeneration	Promote regeneration of vegetation in areas disturbed during construction and not required for production.	Project area regeneration is measured and compared to established regeneration benchmarks.	Percent
	Achieve established benchmarks for regeneration areas.		
Invasive species, pests and plant pathogens	Prevent priority invasive species from entering or establishing in the Project area.	Ingress of new priority invasive species in and between invasive species management zones.	Type, abundance and distribution

ASPECT	OBJECTIVE	INDICATOR	MEASUREMENT NOTE 1
	Contain priority invasive species and plant pathogens already established in the Project area.	Increases in abundance and/or distribution of existing priority invasive species and/or plant pathogens in and between invasive species management zones.	Type, abundance and distribution
Ecology	Avoid impacts to specific features of ecological importance.	Condition of specific features of ecological importance assessed: • Level 1 – Minor change to condition of a sensitive/protected habitat or population of an International Union for Conservation of Nature (IUCN) listed (or Papua New Guinea protected) species • Level 2 – Moderate change to condition of a sensitive/protected habitat or population of an IUCN listed (or Papua New Guinea protected) species • Level 3 – Major change of condition of a sensitive/protected habitat or population of an IUCN listed (or Papua New Guinea protected) species	Significance of change to the condition of specific ecological features
Access	Control vehicle access to Project roads and infrastructure to prevent potentially damaging third party activities.	Unauthorised access to Project roads and infrastructure. Third party access requests and EHL approvals granted to access Project controlled roads and infrastructure.	Number and frequency
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.			

21.0 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.

21.1 Incident management

OIMS System 9-1 Incident Management defines the incident management process to be followed by EHL 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. EHL's Incident Management Guide defines types of incidents and their Severity Level.

In general, environmental incidents 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, regardless of the Severity Level, 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 EHL's incident management requirements.

21.2 Incident notification and reporting

All environmental incidents will be documented, notified and reported in accordance with EHL's Incident Management Guide, 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 (<0, 0, 1, 2, 3).

21.2.1 Internal notification and reporting

Environmental incidents are notified and reported in accordance with the Incident Management Guide.

21.2.2 Statutory notification and reporting

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

Condition 95 of the Environment Permit requires EHL to promptly report to the DEC 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 (1,600 litres).

21.2.3 Notification and reporting to the 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 EHL's incident notification and reporting requirements.

22.0 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 and Commitment, which contains requirements pertaining to the allocation of resources.

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

EHL's E&R organisation is allocated primary responsibility for the implementation of this EMP. In addition to the SHE and E&R organisations, other EHL production and maintenance personnel have defined roles and responsibilities regarding this EMP. Roles and responsibilities of key personnel are outlined in Table 22-1.

Table 22-1: Roles and responsibilities

ROLE	RESPONSIBILITY
Upstream Operations Superintendent	• Overall accountability for conformance with the requirements of this EMP • Ensure operational resources are allocated for the effective implementation of this EMP, in respect of the Upstream operations
SHE Manager	• Overall responsibility for conformance with the requirements of this EMP
Hides and Angore Wellpad Operations Manager	• Accountable for conformance with the requirements of this EMP pertaining to the Hides and Angore Wellpads. • Ensure operational resources are allocated to the effective implementation of this EMP, in respect of the Hides and Angore Wellpads
HGCP Manager	• Accountable for conformance with the requirements of this EMP pertaining to the HGCP • Ensure operational resources are allocated to the effective implementation of this EMP, in respect of the HGCP
HWMF Manager	• Accountable for conformance with the requirements of this EMP pertaining to the HWMF • Ensure operational resources are allocated to the effective implementation of this EMP in respect of the HWMF • Direct the HWMF Contractor
E&R Supervisor	• Ensure environmental resources are allocated to the effective implementation of this EMP

23.0 COMPETENCY, TRAINING AND AWARENESS

Information relating to competency, training and awareness regarding the implementation of this EMP is provided in this section. EHL 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, Placement and Competency Verification and OIMS System 5-2 Personnel Training.

23.1 Competency

In accordance with OIMS System 5-1 Personnel Selection, Placement and Competency Verification, EHL 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 will be identified.

23.2 Training and awareness

In accordance with OIMS System 5-2 Personnel Training, EHL 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 23-1.

Table 23-1: Training and awareness

TYPE OF TRAINING	DESCRIPTION
Induction	Induction is provided to visitors. Inductions include a summary of key environmental aspects, controls and other 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 is provided to management and supervisors. The training includes key aspects of this EMP.
Job-specific training	Job-specific training is provided to personnel who have direct duties in this EMP. The training includes 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.

23.3 Training of third parties

EHL 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.

In the case of landowner/community service providers involved in the management of erosion and sediment and invasive species (Section 13.0 and Section 15.0), EHL will provide training as necessary for landowner/community representatives.

24.0 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 all data relating to this EMP and is designed to handle and manipulate data as required (for example tracking and trend analysis) to facilitate reporting.

25.0 REPORTING

25.1 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 EHL management.

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

25.2 External reporting

25.2.1 Reporting to Department of Environment and Conservation

Pursuant to the Environment Permit, EHL will submit periodic environmental reports to the DEC. The reports 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-construction surveys undertaken in the reporting period, and other information as relevant to this EMP.

25.2.2 Reporting to the Lender Group

Pursuant to the Common Terms Agreement, EHL will submit a biannual/annual production Environmental and Social Report to the Lender Group and the IESC.

The Environmental and Social Report 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-construction surveys undertaken and other information as relevant to this EMP.

26.0 REFERENCES

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27.0 APPENDICES

Appendix 1: Environmental Impact Statement mitigation measures
Appendix 2: Summary of emissions and discharges
Appendix 3: Regeneration monitoring program

APPENDIX 1: ENVIRONMENTAL IMPACT STATEMENT MITIGATION MEASURES

IFC PERFORMANCE STANDARD THEME	MITIGATION MEASURE REFERENCE	MITIGATION MEASURE	EMP SECTION REFERENCE
Performance Standard 3: Pollution Prevention and Abatement (IFC, 2006) Pollution Prevention, Resource Conservation and Energy Efficiency	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 sewage treatment plants in accordance with the manufacturer's specifications and comply with the conditions of discharge quality specified in the Environment Permit.	Section 9.0
	M134, M135, M149	Treat all water and wastewater discharges as necessary to comply with the prescribed conditions for discharge quality established 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
	M168	At the HGCP, waste heat from the exhaust of the pipeline compressor gas turbines will be used to provide heat to the thermal fluid-based hot oil system.	Section 6.0
	M171	Adhere to specific criteria that are aligned to the intent of the IFC and World Health Organization guidelines. A boundary 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 landowners.	Section 8.0
	M174	Notify potentially affected persons of intended high intensity work and its duration.	Section 8.0
	M176	Diesel powered equipment will be regularly serviced and low-sulphur diesel used where practicable.	Section 6.0
	M179	BTEX emissions will be treated by thermal destruction or industry good practice.	Section 6.0
	M180	Low mono-nitrogen oxides emissions equipment will be fitted on the turbine generators and gas compressors.	Section 6.0
Performance Standard 3: Pollution Prevention and Abatement (IFC, 2006) Pollution Prevention and Abatement: Waste	M92	Dispose of waste to EHL-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 EHL-approved facilities; dispose of ash to EHL approved landfills.	Section 12.0
	M98	Track all waste to be disposed or recycled.	Section 12.0

IFC PERFORMANCE STANDARD THEME	MITIGATION MEASURE REFERENCE	MITIGATION MEASURE	EMP SECTION REFERENCE
	M103	Establish procedures for waste that comply with applicable parts of the *General Environmental, Health and Safety (EHS) 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 60] (United States Environmental Protection Agency, 2008)*, Subpart AAAA or CCCC as applicable.	Section 12.0
	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
Performance Standard 3: Pollution Prevention and Abatement (IFC, 2006) Hazardous Materials	M100	Establish appropriate procedures for fuel handling transport and storage.	Section 10.0
	M101	Establish appropriate procedures for materials handling, storage and disposal.	Section 10.0
	M102	Establish appropriate procedures for the storage and handling of radioactive materials.	Section 11.0
	M146	Fuel and chemical 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 10.0
	M131	MEG slop storage tanks will be purpose-built full-containment tanks and bunded.	Section 10.0
Performance Standard 3: Pollution Prevention and Abatement (IFC, 2006) Emergency Preparedness and Response	M130	Hydrocarbon spill prevention and response procedures will be detailed in the Oil Spill Contingency Plan.	Section 10.0
	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 10.0
	M151	An appropriate number of staff will be trained in the handling of emergency response and spill scenarios.	Section 10.0
Performance Standard 3: Pollution Prevention and Abatement (IFC, 2006) Pesticide Use and Management	M80	Use herbicides only for the eradication of a serious invasive weed if considered to be most effective control.	Section 11.0
Performance Standard 6: Biodiversity Conservation and Sustainable Natural Resource Management (IFC, 2006)	M50	Prohibit transportation of live animals, plants or seeds to the Hides Ridge area.	Section 15.0
	M53	Prohibit establishment of gardens with introduced plants and introduction of exotic plants or animals.	Section 15.0
	M54, M222	Establish and enforce a Project-wide quarantine program.	Section 15.0

IFC PERFORMANCE STANDARD THEME	MITIGATION MEASURE REFERENCE	MITIGATION MEASURE	EMP SECTION REFERENCE
	M57	Prohibit disturbance/harassment of wildlife, hunting of fauna, gathering of plants or bush foods, collection of firewood or possession of wildlife products by Project workers or contractors while working, travelling in Project vehicles, and residing in Project field accommodation. Implement appropriate inductions and education to encourage staff to comply with regulations.	Section 16.0
	M58	Implement appropriate inductions to encourage staff to comply with hunting and collecting regulations.	Section 16.0
	M75	Undertake site reinstatement promptly and progressively and as soon as possible after disturbance, taking into account the nature of subsequent project activities and agreed end uses.	Section 14.0
	M77	The design criteria for RoW width on Hides Ridge is 18 metres. During production, the RoW will be allowed to regenerate except for a 10-metre wide access road required for ongoing drilling and maintenance access.	Section 14.0
	M88	Control access for all new Project road sections constructed for logistics transfer between Kopi and the HGCP, for Project use only following completion of construction.	Section 16.0
	M89	Make the new Project roadways and all pipeline RoW's between the Omati River Landfall and the Kopi deviation impassable at the end of Project construction.	Section 16.0
	M90	Control access to Hides Ridge west of Hides Wellpad A and implement a permit system for vehicle access for the duration of construction.	Section 16.0
	M104	Direct lighting at facilities to reduce illumination of the surrounding forest to reduce disturbance to nocturnal fauna, where security allows.	Section 6.0
	M106	Conduct surveys along RoW, facility sites and supporting infrastructure of sensitive features and develop appropriate mitigation measures.	Section 16.0
	M107, M108	Establish cave management protocols to restrict access to caves with bats and prohibit unnecessary disturbance of bat colonies.	Section 16.0
	M111	Control speed limits via posted speed limit signs and keep vehicles to marked trafficable areas.	Section 16.0
	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 weeds, pests 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 Ecology, Natural Habitat and Biodiversity Management Plan and appropriate control measures will be taken.	Section 15.0
	M137	Water taken from watercourses or groundwater will meet Environment Permit conditions.	Section 11.0

IFC PERFORMANCE STANDARD THEME	MITIGATION MEASURE REFERENCE	MITIGATION MEASURE	EMP SECTION REFERENCE
	M152	Conduct post-construction inspections along the RoW within the catchment of Lake Kutubu including: checking for problematic erosion areas and implementing remedial works as appropriate, inspecting ditches and culverts and removing accumulated debris, where required and reviewing water quality monitoring results for advance warning of deteriorated water quality due to increased suspended sediment loading.	Section 12.0
	M162, M165	The construction and rehabilitation of the RoW in the Omati River swamp area will be managed to maintain natural hydrologic flows and connectivity in the surrounding area. Monitoring of vegetation condition in the vicinity of the RoW will be conducted to assess the need for post construction remedial works in this area.	Section 13.0
Performance Standard 8: Cultural Heritage (IFC, 2006)	M230	Develop and implement a cultural heritage management plan in consultation with the National Museum and Art Gallery, archaeologists and cultural heritage specialists.	Section 17.0
	M239	Periodically monitor cultural sites within the vicinity of pipelines and facilities to ensure Project personnel are not disturbing these sites.	Section 17.0
Note: The language of some measures has been revised since the EIS to better reflect actual circumstances and provide greater clarity.			

APPENDIX 2: SUMMARY OF EMISSIONS AND DISCHARGES

SUMMARY OF EMISSIONS TO AIR					
LOCATION	**SOURCE** NOTE 1	**NATURE**	**POLLUTANTS** NOTE 2	**GUIDELINE**	**MONITORING**
HGCP	Compressor gas turbines	Continuous	Oxides of nitrogen	25 ppm NOTE 3	Annual stack test NOTE 4
	Main power generators			42 ppm NOTE 3	
	MEGVG incinerator		BTEX	N/A	
	Low pressure flare (purge and pilot gas)		Oxides of nitrogen	N/A	N/A
	High pressure flare (purge and pilot gas)		Oxides of nitrogen	N/A	N/A
	Essential services generators	Intermittent	Oxides of nitrogen, carbon monoxide, sulphur dioxide	N/A	N/A
	Diesel firewater pump engine				
	Industrial waste incinerator		Waste dependent NOTE 5	PM: 70 mg/m^3 NOTE 6	Annual stack test 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	
HWMF	Incinerator			Opacity: 10 percent	
	Diesel engine generators	Continuous	Oxides of nitrogen, carbon monoxide, sulphur dioxide	N/A	N/A
HWVF	Diesel engine generators				
Komo Airfield	Diesel engine generators				
	Essential services generators	Intermittent			
	Firewater pump diesel engines				
AGIs NOTE 7	Diesel engine generators	Continuous (day)			

SUMMARY OF DISCHARGES TO WATER					
DISCHARGE TYPE	**SOURCE**	**NATURE**	**POLLUTANTS AND GUIDELINE VALUES** NOTE 8		**MONITORING**
Stormwater	HGCP HWMF Komo Airfield Above Ground Facilities	Intermittent	pH	6.5 – 9 (pH units) NOTE 9	Periodic in-situ sampling
			Turbidity	No alteration greater than 25 NTU or no change > 10 percent from background levels at any particular time (whichever is greater)	
			Dissolved oxygen	Not less than 6 mg/L or no change > 10 percent from background levels at any particular time (whichever is greater)	
			Total Suspended Solids	50 mg/L or no change > 10 percent from background levels at any particular time (whichever is greater)	
			Oil and grease	No visible film (for construction discharges) 10 mg/l (for production discharges)	
Wastewater Treatment Plant	HGCP HWMF Sludge Dewatering System Komo Airfield	Intermittent	pH	6.5 – 9 (pH units) NOTE 10	Periodic in-situ sampling
			Biological oxygen demand	25 mg/l	
			Chemical oxygen demand	125 mg/l	
			Ammonia-nitrogen	Dependent on pH and temperature (Table 9-5)	
			Total Suspended Solids	50 mg/L or no change > 10 percent from background levels at any particular time (whichever is greater)	
			Oil and grease	No visible film (for construction discharges) 10 mg/l (for production discharges)	
			Faecal coliform	Not to exceed 200 colonies per 100 ml or no change > 10 percent from background levels at any particular time (whichever is greater)	
Process	HGCP HWMF	Intermittent	pH	6.5 – 9 (pH units) NOTE 11	Periodic in-situ sampling
			Temperature	No alteration greater than 2 degrees Celsius	
			Insoluble residues	No insoluble residues or sludge formation to occur	
			Dissolved oxygen	Not less than 6 mg/L or no change > 10 percent from background levels at any particular time (whichever is greater)	
			Chemical oxygen demand	125 mg/l	
			Biological oxygen demand	25 mg/l	

SUMMARY OF DISCHARGES TO WATER					
DISCHARGE TYPE	**SOURCE**	**NATURE**	**POLLUTANTS AND GUIDELINE VALUES** NOTE 8		**MONITORING**
Process (cont.)	HGCP HWMF (cont.)	Intermittent	Sulphate as $SO4^{2-}$	400 mg/l	Periodic in-situ sampling
			Sulphide as HS-	0.002 mg/l	
			Ammonia-nitrogen	Dependent on pH and temperature (Table 9-5)	
			Nitrate	45 mg/l	
			Potassium	5.0 mg/l	
			Barium	1.0 mg/l	
			Boron	1.0 mg/l	
			Cadmium	0.01 mg/l	
			Chromium (as hexavalent)	0.05 mg/l	
			Cobalt	Limit of detection	
			Copper	1.0 mg/l	
			Iron	1.0 mg/l	
			Lead	0.005 mg/l	
			Manganese	0.5 mg/l	
			Mercury	0.0002 mg/l	
			Nickel	1.0 mg/l	
			Selenium	0.01 mg/l	
			Silver	0.05 mg/l	
			Tin	0.5 mg/l	
			Zinc	5.0 mg/l	
			Oil and grease	No visible film (for construction discharges) 10 mg/l (for production discharges)	
			Phenols	0.002 mg/l	
Leachate	HWMF	Intermittent	As for process wastewater above (NOTE 4), plus: Turbidity: No alteration greater than 25 NTU or <10 percent change from background levels at any particular time Total Suspended Solids: 50 mg/L or <10 percent change from background levels at any particular time		Periodic in-situ sampling

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

Note 2: Includes only the key pollutants of relevance.

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

Note 4: Stack tests will be undertaken twice yearly for the first two years of operations, thereafter annually.

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

Note 6: All incinerator parameters 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: All MLVs, Kopi Scraper Station and the CP Stations.

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

Note 9: Annex 2 of EHL's Environment Permit, based on *Environment (Water Quality Criteria) Regulation 2002*, Water Quality Criteria for Aquatic Life Protection. The criteria shown are extracted from the Schedule 2 of the *Environment (Water Quality Criteria) Regulation 2002* as relevant to the discharge of stormwater from uncontaminated areas. NTU = nephelometric turbidity unit.

Note 10: Annex 2 of EHL's Environment Permit, based on *Environment (Water Quality Criteria) Regulation 2002*, Water Quality Criteria for Aquatic Life Protection. The criteria shown are extracted from the Schedule 2 of the *Environment (Water Quality Criteria) Regulation 2002* as relevant to the discharge of WWTPs. The criteria for faecal coliform bacteria is based on not fewer than five water samples collected over not more than a 30-day period.

Note 11: Annex 2 of EHL's Environment Permit, based on Environment (Water Quality Criteria) Regulation 2002, Water Quality Criteria for Aquatic Life Protection. The criteria shown are extracted from the Schedule 2 of the Environment (Water Quality Criteria) Regulation 2002 as 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.

APPENDIX 3: REGENERATION MONITORING PROGRAM

Purpose and objectives

The regeneration monitoring program is based on surveys of regenerating areas to collect and analyse data relating to the succession of vegetation and condition of forest. The overall objective is to evaluate regeneration performance.

Areas disturbed for temporary construction facilities and infrastructure were 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. Following reinstatement, successional regeneration is predicted by EHL to progress to the original forest state as measured by structure and tree species composition.

The regeneration monitoring program uses a combination of fixed and random sampling and a benchmarking scoring system to monitor the progression of successions in regenerating areas and the condition of forest adjacent to linear infrastructure to monitor edge effects.

Benchmarking method

The regeneration monitoring program is based on a condition assessment or benchmark approach whereby the condition of vegetation on a given plot is compared with a benchmark, which represents the average characteristics of natural forest of the same type and at the same stage of regeneration, in other words it evaluates whether the structural state of a given regenerating area is within normal range for that specific vegetation type of that specific age.

The basis for benchmarking has been established by determining the range of forest types to sample, developing the parameters that would form a benchmark, establishing the benchmarks by measuring sites (benchmark plots) of known regeneration age, and designing sample plot layouts.

The EIS identified 21 Broad Vegetation Groups in the Upstream Project Area. A Broad Vegetation Groups is a broad grouping of vegetation types from the Forest Inventory Mapping Systems, which is commonly used in biodiversity surveys in Papua New Guinea.

For the purposes of the regeneration monitoring program, the Broad Vegetation Groups identified in the EIS have been categorised into forest-terrain combinations termed Benchmark Vegetation Groups. Examples of Benchmark Vegetation Groups include:

- Lower montane very small crowned forest complexes
- Swamp forest complexes
- Medium crowned to small crowned forest complexes
- Swamp woodland and forest complexes
- Open lowland forest

To develop the benchmarks, published systems of forest mensuration were reviewed and modified to produce a catalogue of parameters that includes vegetation physiognomy, ground condition and species composition. The values for each parameter can be reported individually or combined using various algorithms into a condition index. Ranges of values for each parameter were obtained from benchmark plots of known regeneration age (the benchmark plots are removed from EHL's facilities and infrastructure).

The benchmark plots are not control plots in the experimental sense, but areas sampled to provide a picture of natural variation of the parameters to provide the benchmark against which monitoring plots are compared.

Sampling method

The regeneration monitoring program is based on a combination of sampling methods using fixed and random plots. Fixed plots provide lower variance of estimated change between sampling events however the ongoing availability of fixed plots is difficult to guarantee (for example due to withdrawal of landowner cooperation, conversion to gardens or changes in accessibility).

Sampling is based on a sampling unit of three plots in a line at right angles to the pipeline RoW. Regeneration is monitored in a Plot A, located within an area of the pipeline RoW which is regenerating. Forest condition adjacent to the pipeline RoW is monitored in a Plot B located in forest adjacent to the Plot A. A third Plot C is located distant (approximately 200 to 300 metres) from Plot B to detect any confounding effects which may result from broad scale forest changes.

Sampling is undertaken at locations which are safely accessible and where the original vegetation (prior to disturbance during construction) and was old growth forest.

There are between four and six sample sites within each Benchmark Vegetation Groups. In determining the optimum number of sample sites, the methodology of the Tropical Ecology Assessment and Monitoring Network (TEAM Network, 2010) has been used as a guide.

The number of sites designated to be sampled within each Benchmark Vegetation Groups is an optimisation between cost and accuracy of estimates of the deviations from benchmark values.

Frequency and output

Data collection, processing, analysis and reporting will be undertaken every other year until 2020 and every three years thereafter. It is useful to consider in this regard that an initial rapid colonisation of pioneer and secondary plant species is expected immediately following reinstatement, with subsequent gradual maturation of the succession and an increase in frequency of primary forest species.

The regeneration monitoring program requires appropriate technical expertise and experience, therefore a specialist organisation will be contracted to advise and participate in each campaign. Opportunities for community participation (participatory monitoring) will be evaluated and taken forward where appropriate.

The output from each campaign is a technical report which provides information describing succession of vegetation and condition of forest, with analysis of trends where applicable.

Further details regarding the regeneration monitoring program are provided in the Regeneration Monitoring Protocol.