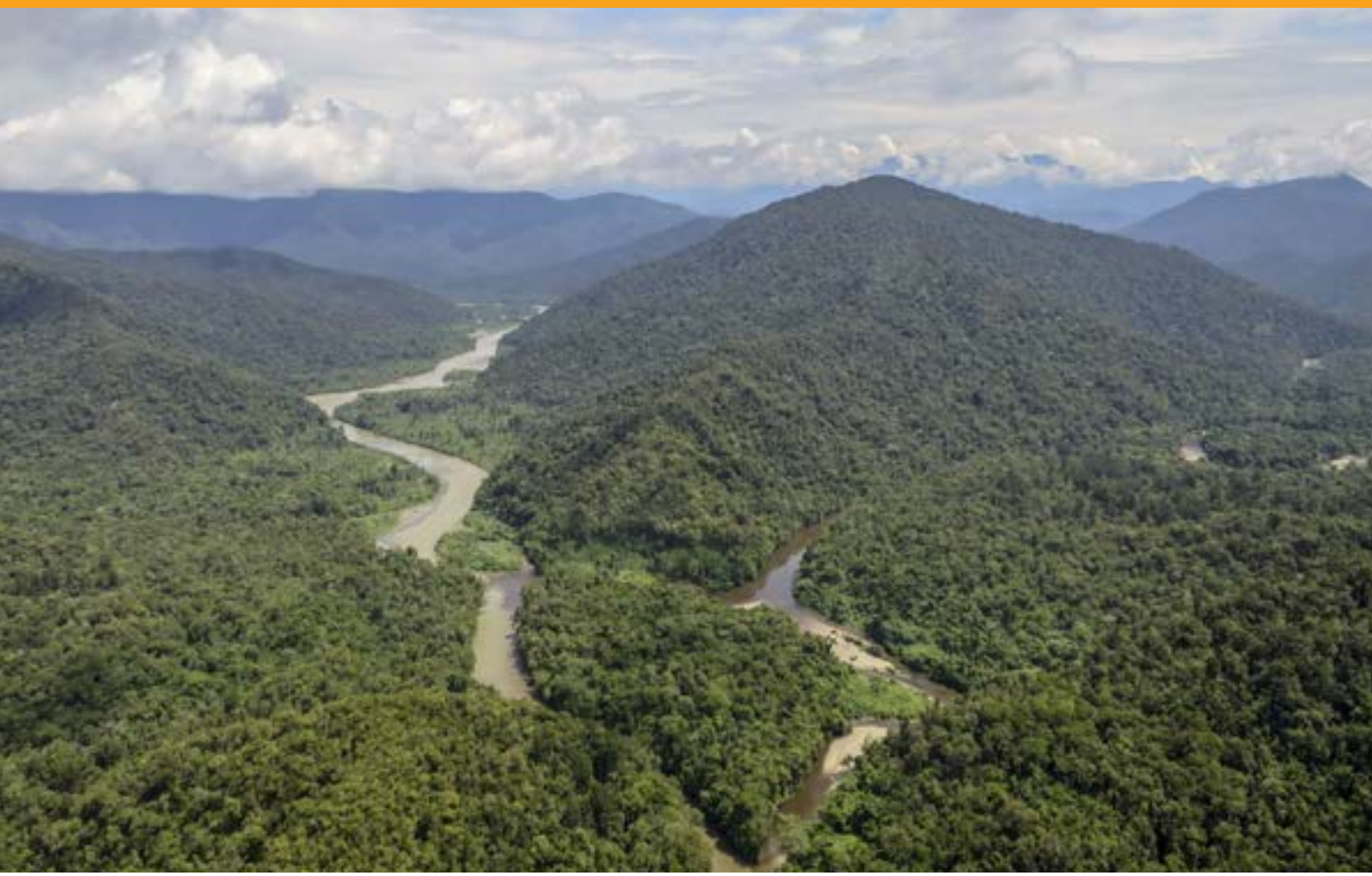
FRIEDA RIVER

Frieda River Limited
Sepik Development Project
Environmental Impact Statement

Chapter 12 – Environmental and Social Management, Monitoring, Auditing and Reporting Framework

SDP-6-G-00-01-T-084-013



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12. ENVIRONMENTAL AND SOCIAL MANAGEMENT, MONITORING, AUDITING AND REPORTING FRAMEWORK

12.1 Introduction

This chapter outlines the framework for environmental and social management, monitoring, auditing and reporting for the Project. The framework considers the requirements under which the Project will be constructed and operated, and describes the proposed organisational structure under which the management, monitoring, auditing and reporting will be carried out. The framework was developed from the governance model established by the PanAust Group Sustainability Policy (Figure 3.2). The Sustainability Policy is supported by 14 Sustainability Management Standards relating to leadership, risk management, health and safety, training, environment, stakeholder engagement and community, which have been developed to ensure consistent sustainability-related outcomes across the business activities managed by PanAust and its subsidiaries including FRL.

12.2 Sustainability Management Standards

The Sustainability Management Standards describe the processes that will be implemented to demonstrate compliance with applicable sustainable development legislation and guidelines through an effective management system.

The four key components of 'sustainability' as defined in the Sustainability Management Standards include:

1. Health: promoting and improving the health of the workforce and working with local communities in health and hygiene initiatives and improvements.
2. Safety: a state in which the risk of harm (to persons) or damage is limited to an acceptable level.
3. Environment: efficient use of natural resources, recycling, reducing and preventing pollution, protecting biodiversity and rehabilitating disturbed land.
4. Social: a diverse workforce where employees and contractors are treated fairly and with respect. The upholding of ethical business practices and fundamental human rights is expected and the enhancement of economic benefits and sustainable community development is promoted.

The Sustainability Management Standards provide procedures for implementing, achieving, reviewing and maintaining PanAust's Sustainability Policy. Good industry environmental management practice is also incorporated into the Sustainability Management Standards.

The Project will implement a risk-based management system in accordance with the Sustainability Management Standards. The system was developed in reference to the following:

- AS ISO/NZS 31000: Risk Management Standard (AS/NZS, 2009).
- OHSAS 18001: Occupational health and safety management systems (BSI, 1999).
- ISO 14001: Environmental management systems (ISO, 2016).
- Enduring Value: Framework for Sustainable Development (MCA, 2015).
- Equator Principles: Managing social and environmental risk in project financing (EPFI, 2013).

- IFC performance standards (IFC, 2012a).
- Global Reporting Initiative: Sustainability Reporting Guidelines (GRI, 2014).

The standards provide auditable criteria against which operational performance systems can be measured. The standards are reviewed annually or as determined through the monitoring, audit and review process. If required, the standards are revised and reissued in accordance with the document control requirements, thus embedding a process of continuous improvement.

The key elements of the environmental and social management framework that sits under the Sustainability Management Standards are presented in Figure 12.1 and described in the following sections.

12.3 Environmental Management and Monitoring Plans

The Project's environmental management and monitoring plans (EMMPs) will be implemented within the Sustainability Management Standards framework to address the management, monitoring, auditing and reporting requirements for construction, operation and decommissioning.

Construction EMMPs specific to each of the interdependent projects that make up the Sepik Development Project have been prepared as follows:

- Frieda River Copper-Gold Project EMMP.
- Frieda River Hydroelectric Project EMMP.
- Sepik Power Grid Project EMMP.
- Sepik Infrastructure Project: Public Road from Vamino to Hotmin EMMP.
- Sepik Infrastructure Project: Green River Airport EMMP.
- Sepik Infrastructure Project: Vamino Ocean Port EMMP.

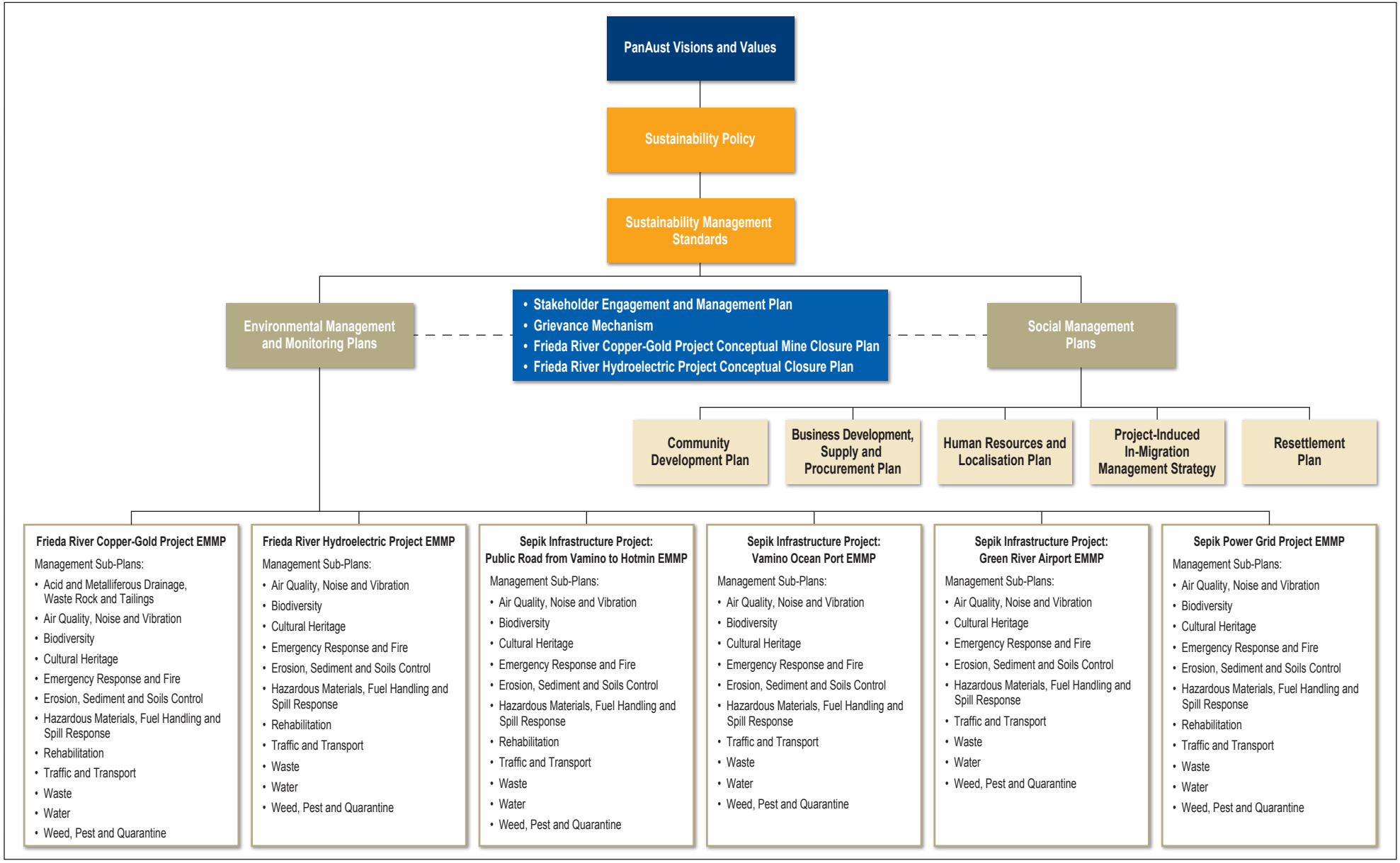
The EMMPs reflect the commitments contained in the EIS, particularly in chapters 8 and 9, and describe the programs that support their implementation. The processes for monitoring, auditing and checking for compliance against these commitments are also described.

The EMMPs are included as Attachment 2.

Subsequent EMMPs addressing the operation phase will be prepared and submitted to CEPA no less than six months prior to commissioning. The EMMPs take into account the commitments made in this EIS, which are collated in the commitments register provided in Attachment 1, and will be updated to incorporate the relevant conditions of the environment permit, once granted.

The aims of the EMMPs are to:

- Document the Project's approach to environmental management including the environmental management system, schedule for environmental management and organisational structure and responsibilities.
- Describe how environmental risks will be addressed, together with the social management plans (Section 12.4), based on the 'in principle' commitments described in this EIS.
- Detail an integrated program to monitor, manage, audit and report on environmental impact predictions and compliance with regulatory permits and licences.
- Document auditable commitments made by the Project for reference in future internal and external audits.



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Date: 01.11.2018
Project: 754-ENAUABTF11575B
File Name: 11575_11_F12.01_GRA

Frieda River Limited

Sepik Development Project

FRIEDA RIVER

Environmental and social management framework

Figure No: 12.1

AI Reference: 11575_11_GRA046.ai_8

The Project's management measures will be based on a hierarchical approach determined by technical feasibility, cost and benefit, and will involve avoiding, and mitigating or limiting of the impact.

The EMMPs have been prepared with two main components: introduction and context, and management sub-plans. The structure of each EMMP is as follows:

Introduction and Context

The initial sections of each EMMP will consist of introductory and contextual information including:

- Introduction:
  - Project overview.
  - Rationale for EMMP.
  - Structure of this EMMP.
- Regulatory framework:
  - Statutory context.
  - National legislation.
  - Provincial and local legislation.
- Existing environment:
  - Physical and biological setting.
  - Socio-economic setting.
- Project activities.
- Environmental management framework:
  - Environmental management system.
  - Policy.
  - Implementation.
  - Checking and corrective action.
- Environmental monitoring:
  - Approach.
  - Program.
  - Quality control.
- References.

Management Sub-Plans

Issue-specific management sub-plans describe the environmental objectives and management measures that will be implemented to mitigate impacts that may occur. The sub-plans included in each EMMP are as follows:

- Air Quality, Noise and Vibration Management Sub-Plan.
- Biodiversity Management Sub-Plan.
- Cultural Heritage Management Sub-Plan.
- Emergency Response and Fire Management Sub-Plan.
- Erosion, Sediment and Soils Control Management Sub-Plan.
- Hazardous Materials, Fuel Handling and Spill Response Management Sub-Plan.
- Rehabilitation Management Sub-Plan.
- Traffic and Transport Management Sub-Plan.
- Waste Management Sub-Plan.

- Water Management Sub-Plan.
- Weed, Pest and Quarantine Management Sub-Plan.

The FRCP EMMP will also include an Acid and Metalliferous Drainage, Waste Rock and Tailings Sub-Plan. Given the importance of this sub-plan and the Water Management Sub-Plan, these sub-plans cover both the construction and operation phases of the Project.

The Sepik Infrastructure Project: Green River Airport EMMP does not include a Biodiversity Management Sub-Plan as the facility is situated on previously disturbed land.

12.4 Social Management Plans

Management plans will be developed and implemented to address the social aspects of the Project, aimed at maximising benefits to stakeholders and limiting adverse impacts during construction, operation and closure. These plans will include:

- Community Development Plan.
- Business Development, Supply and Procurement Plan.
- Human Resources and Localisation Plan.
- Project-Induced In-Migration Management Strategy.
- Resettlement Plan.

Site-specific resettlement action plans will also be developed under the overarching Resettlement Plan.

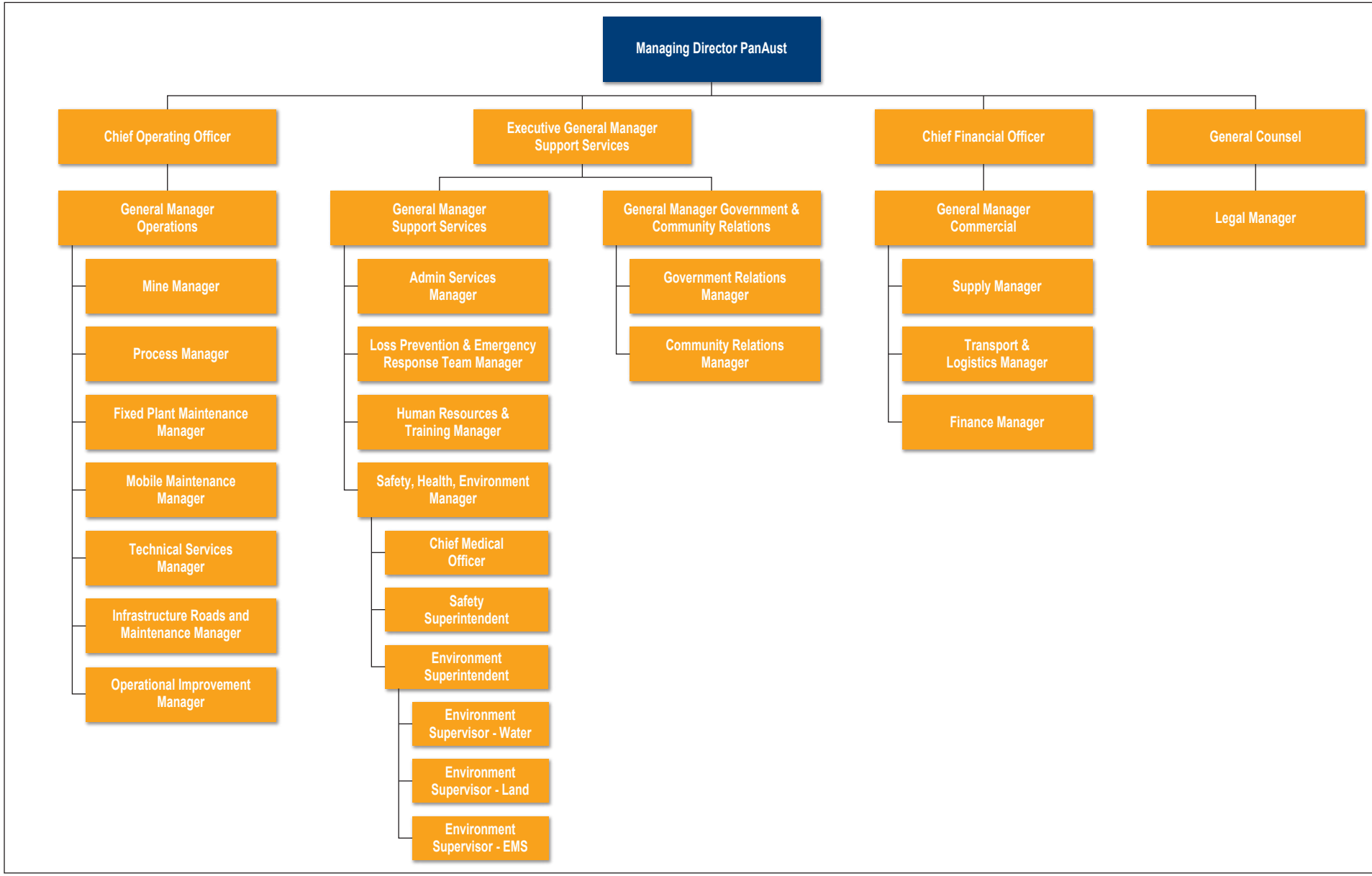
The social management framework includes the Stakeholder Engagement and Management Plan and the Grievance Mechanism which are essential for maintaining a constructive dialogue with potentially affected individuals and communities. The inclusion of the FRCGP Conceptual Mine Closure Plan and FRHEP Conceptual Closure Plan also provides a reference for the management plans to promote capacity development aimed at mitigating the social impacts of eventual FRCGP closure.

12.5 Organisational Structure and Responsibilities

Figures 12.2 and 12.3 show the proposed operations organisation charts for the FRCGP and FRHEP, respectively. Management roles will ensure that activities comply with the environment permit conditions and the EMMPs. FRL will also ensure that its contractors and sub-contractors are contractually bound to ensure that their activities also comply with the environment permit conditions and the EMMPs.

The Sustainability Policy and the Sustainability Management Standards are approved by PanAust's Managing Director. The Sustainability Policy, management standards, risks and performance are subject to regular review by the PanAust Risk and Sustainability Department. Operations management develop and implement any additional documentation for their operations, where required, in keeping with the Sustainability Management Standards' hierarchical requirements.

Operations managers provide resources to adequately support effective management, implementation and maintenance of the Sustainability Management System and are accountable for the performance of sustainability-related measures within their department, including implementation.



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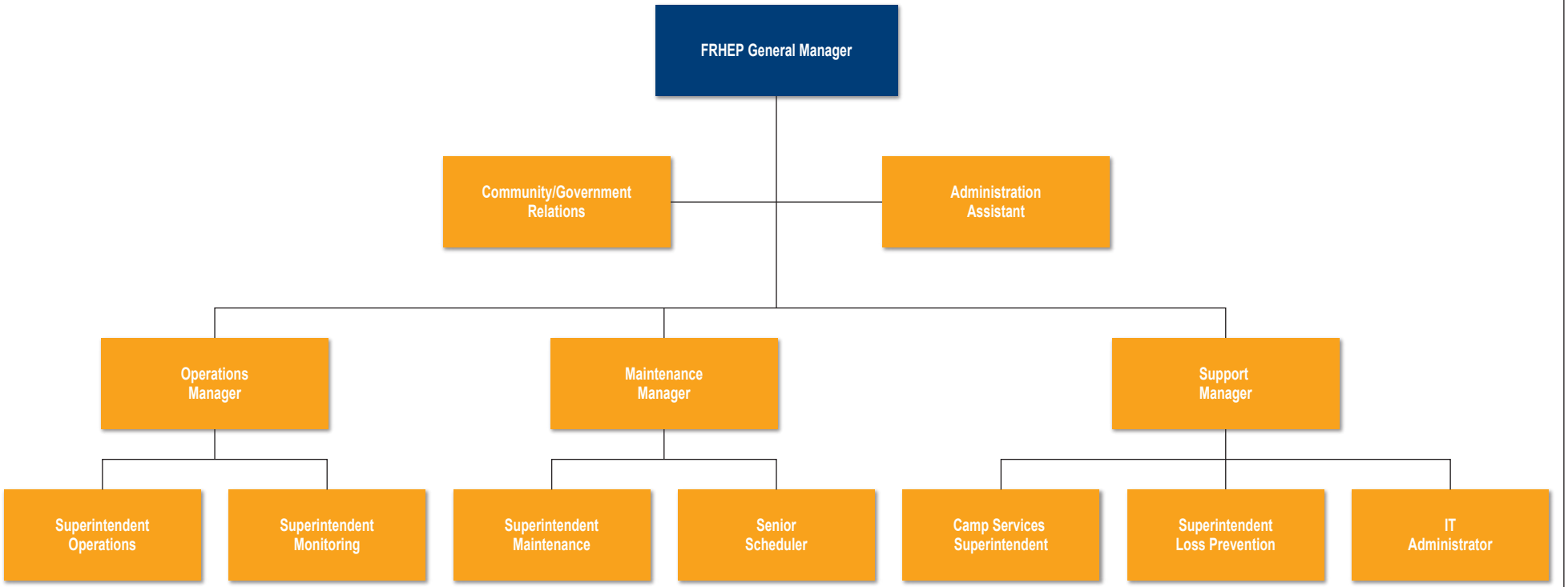

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For the FRCGP, the General Manager Operations and General Manager Government and Community Relations will be responsible for ensuring that activities associated with FRL's activities are undertaken in full compliance with all statutory regulations and are consistent with the Sustainability Policy. The General Manager Operations and General Manager Government and Community Relations will report to PanAust's Chief Operating Officer and Executive General Manager Support Services, respectively. The management of environmental aspects will be the responsibility of the Safety, Health, Environment (SHE) Manager who will report to the General Manager Support Services. The Community Relations Manager will be responsible for managing social aspects and will report to the General Manager Government and Community Relations.

For the FRHEP, the General Manager will be responsible for ensuring that activities associated with FRL's activities are undertaken in full compliance with all statutory regulations and are consistent with the Sustainability Policy. The General Manager Operations will report to PanAust's Chief Operating Officer. The management of environmental aspects will be the responsibility of the Superintendent Operations who will report to the Operations Manager. The Community/Government Relations Manager will be responsible for managing social aspects and will report to the General Manager.

Individual responsibilities and accountabilities will be defined through position descriptions and conditions of contracts of employment. Furthermore, environmental and social responsibilities will be written into the service agreements for contractors.

Organisation structures for operation of the SPGP and SIP will be developed and documented in the operations EMMPs.

12.6 Monitoring, Auditing and Reporting

12.6.1 Approach

The purpose of environmental monitoring for the Project will be to verify the impact predictions contained in this EIS, confirm effective implementation of environmental management measures and to demonstrate compliance with regulatory permits and licences. Where necessary, corrective action will be taken should monitoring indicate that environmental and/or social management measures are not effective.

12.6.2 Monitoring

Monitoring for the construction of the Project is described in each of the EMMPs (Attachment 2) and Social Management Plans, and will include the following monitoring methods:

- **Baseline monitoring.** Establishes a baseline for a range of aspects (e.g., physical, biological and social) requiring information which is additional to that gathered in the EIS. This will be finalised prior to construction.
- **Construction monitoring.** Ensures effective implementation of environmental and social management measures and ensures that construction is completed in accordance with the environment permit and other commitments outlined within the construction EMMPs.
- **Post-construction monitoring.** Conducted to validate and monitor predicted impacts from construction activities.

The operations monitoring program will be covered in the operations EMMPs that will be developed and submitted to CEPA at least six months prior to commencement of commissioning.

This will include the following methods:

- **Operations Monitoring.** Allows for general monitoring of the operation that will take place on a routine basis. The aim is to enable operators at this initial level of surveillance to identify environmentally significant incidents. For example, operational monitoring for the FRCGP includes the following:
  - Ore and mine waste production.
  - Diesel and other consumables usage rates.
  - Potable water quality.
  - Treated sewage effluent quality.
  - Waste production and recycling rates.
  - Open-pit water quality.
  - Tailings chemistry.
  - ISF water quality.
  - ISF water level.
- **Sentinel Monitoring.** Sentinel monitoring records the passage of environmental contaminants or nuisance at points outside the perimeter of the main Project activities. This component of the monitoring system generally aims to record significant unforeseen impacts from discharges of contaminants from the Project. Examples of items for sentinel monitoring include compliance monitoring at the end of the freshwater mixing zone downstream from the ISF (at AP7, see Section 8.5) and the edge of the marine mixing zone related to the discharge of excess filtrate water from the concentrate thickener into Dakriro Bay (see Section 8.10).
- **Ambient Monitoring.** While operations and sentinel monitoring determines if environmentally significant releases have occurred, effects on the receptors within the receiving environment will be determined through the ambient monitoring program, including air quality, noise and local community aspects (e.g., community health, sustainable commercial ventures and use/availability of local bush resources).

Monitoring programs will be further developed as the Project proceeds into detailed design and will take into consideration the conditions of the environment permit. The monitoring programs will typically include the environmental aspects relevant to each Project-related activity, descriptions of the components to be monitored and frequency of monitoring and purpose, where the latter will address both routine ongoing monitoring and intensive ‘validation’ surveys aimed at verifying the predicted impacts, with monitoring frequency then being reduced.

The parameters to be measured will be reviewed and expanded with specific key performance indicators, monitoring locations and frequencies in subsequent iterations of the EMMPs.

Environmental monitoring will be undertaken by the Project’s suitably experienced and qualified personnel and monitoring results will be presented in regular internal reports. The results will also be summarised and reported to government regulators as required by applicable legislation or the environment permit.

12.6.3 Monitoring Parameters and Criteria

Surface Water Quality

Tables 12.1 to 12.3 show the ambient water quality parameters and criteria applicable to the Project, relating to freshwater and marine aquatic ecosystems. Surface water quality sampling will be undertaken on an ongoing basis, the frequency dependent on the receiving water body and analyte.

In the event of an incident, sampling will be carried out immediately and thereafter until water quality has stabilised. Measures to limit the likelihood and severity of incidents are detailed in Chapter 8 and Chapter 10.

In PNG, discharges to water are regulated under the *Environment Act 2000* whereby application is required to CEPA for an environment permit. When granted, the permit will contain a number of conditions, one of which will be the need to comply with prescribed water quality criteria at the downstream limit of a site-specific mixing zone[1] that is applied at the time the permit is granted. These legally enforceable water quality criteria (for fresh and marine receiving waters) are contained in Schedule 1 of the Environment (Water Quality Criteria) Regulation 2002. In addition to the Schedule 1 standard, Schedule 2 of the Public Health (Drinking Water) Regulation 1984 describes enforceable standards for drinking water quality.

There are two water quality compliance points proposed for the Project:

- **Freshwater mixing zone, downstream of the ISF discharge:** AP7 is located on the Frieda River downstream of the ISF and upstream of the existing Paupe village location (see Figure 8.7). At this compliance point, water quality shall comply with PNG Ambient Water Quality Standards (Schedule 1) and PNG Drinking Water Guidelines (Schedule 2) as a regulatory requirement. This compliance point shall be the downstream boundary of the mixing zone. The waters between the discharge location and the compliance point will be a mixing zone where PNG water quality standards and guidelines shall not be required to be met. Where maximum background concentrations of (dissolved and total) parameters measured in the Frieda River (at AP7) exceed the regulatory criteria, the 90th percentile background concentration are proposed as the site-specific criteria. IFC effluent discharge standards (IFC, 2007d) for metals shall be met for discharges from the ISF discharge into the Frieda River with the exception of iron, which is naturally elevated in the receiving Frieda River at the ISF discharge location.

  In addition to compliance with the regulatory criteria, FRL will adopt trigger values for the protection of the aquatic ecosystem based on ANZECC/ARMCANZ (2000) ecosystem protection trigger values (where background concentrations are below these criteria). Site-specific trigger values for copper and aluminium have been developed based on detailed site-specific copper analyses and application of the US EPA Draft Aquatic Life Ambient Water Quality Criteria for Aluminum (2017a and b) (see Section 8.5.5). Exceedance of these trigger values will prompt further investigation such as, but not limited to, review of water quality related management measures, monitoring of additional water quality parameters, review of biological monitoring program or ecotoxicological testing. These trigger levels will be applicable at AP7.

- **Marine mixing zone, associated with the discharge of excess filtrate water from the concentrate thickener:** Treated filtrate water will be discharged into Dakriro Bay. Monitoring of marine water quality will be undertaken to confirm compliance with PNG Ambient Water Quality Standards (Schedule 1) at the mixing zone boundary, which is described in Section 8.10. Monitoring will also be undertaken within the mixing zone boundary where safe to do so and at reference sites away from Project influence. The monitoring will be done at the surface and in the mid-water and lower-water column to account for spatial variability.

[1] A mixing zone is the body of water into which waste is discharged and where the prescribed water quality guidelines are not required to be met. The downstream end of the mixing zone is normally the first location downstream of the proposed discharge point where local people use the river and is called the compliance point.

Table 12.1 Ambient water quality criteria – freshwater aquatic ecosystems[a]

Parameters	Units	Regulatory Criteria	Project trigger levels			
		PNG Schedule 1 Freshwater Aquatic Ecosystems[b]	PNG ECP Freshwater Aquatic Ecosystems[c]	ANZECC/ARMCANZ Trigger Values for Fresh Water[d]	Site-specific trigger values	
					Baseline 90th percentile	Other[e]
General Water Quality Parameters						
Conductivity	µS/cm	–	Less than 1,000 mg/L (about 1,500 µS/cm)	20 to 250	–	–
Dissolved oxygen	mg/L	More than 6.0	More than 6.0 (80 to 90% saturation)	85 to 120% saturation[j]	–	–
pH	–	No alteration to natural pH	6.5 to 9.0	6 to 8[j]	–	–
Total suspended solids	mg/L	–	Less than 10% change[g]	–	–	–
Temperature	°C	Less than 2°C increase	Less than 2°C increase from normal temperature	–	–	–
Turbidity	NTU	No alteration less than 25 NTU	Less than 10% change[g]	2 to 15[j]	–	–
Major Ions and Nutrients						
Ammonia (total)	mg NH_3/L	2.6[f]	0.74[f]	–	–	–
Total phosphorus	mg P/L	–	–	0.1[j]	0.19	–
Total nitrogen	mg N/L	–	–	0.2 to 0.3[j]	–	–
Filterable reactive phosphorous (FRP)	mg/L	–	–	0.004[j]	–	–
Sulphate	mg SO_4/L	400	–	–	–	–
Metals and Metalloids (dissolved)						
Aluminium	mg/L	–	0.1	0.055	–	0.3
Arsenic	mg/L	0.05	0.05	0.013	–	–
Cadmium	mg/L	0.01	<0.00066[h]	0.0002[k]	–	–
Chromium (VI)	mg/L	0.05	–	0.001[k]	–	–
Copper	mg/L	1	<0.0065[h]	0.0014[k]	–	0.020, 0.003 (labile)
Iron	mg/L	1.0 (in solution)	1.0	–	–	–

Table 12.1 Ambient water quality criteria – freshwater aquatic ecosystems[a] (cont'd)

Parameters	Units	Regulatory Criteria	Project trigger levels			
		PNG Schedule 1 Freshwater Aquatic Ecosystems[b]	PNG ECP Freshwater Aquatic Ecosystems[c]	ANZECC/ARMCANZ Trigger Values for Fresh Water[d]	Site-specific trigger values	
					Baseline 90th percentile	Other[e]
Metals and Metalloids (dissolved) (cont'd)						
Manganese	mg/L	0.5 (in solution)	–	1.9	–	–
Mercury	mg/L	0.0002	0.0001	0.00006	–	–
Nickel	mg/L	1	<0.056[h]	0.011[k]	–	–
Lead	mg/L	0.005	<0.0013[h]	0.0034[k]	–	–
Selenium	mg/L	0.01	0.005	0.005	0.01	–
Silver	mg/L	–	0.0001	0.00005	–	–
Zinc	mg/L	5	<0.18[h]	0.008[k]	0.015	–

[a] Applicable at AP7

[b] PNG Environment (Water Quality Criteria) Regulation 2002, Schedule 1. Metal concentrations are for dissolved substances, passing through a nominal 0.45 µm filter.

[c] PNG Environmental Code of Practice (OEC, 2000).

[d] Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000), slightly to moderately disturbed system.

[e] See Section 8.5 for derivation of site-specific criteria.

[f] At pH 7.0 and 30°C. Values are temperature and pH dependent.

[g] From background mean seasonal values.

[h] Based on hardness of <50 mg/L $CaCO_3$.

[j] Lowland rivers.

[k] Based on hardness of 30 mg/L $CaCO_3$.

Table 12.2 Water quality criteria – human health[a]

Parameter	Units	Regulatory Criteria	Project trigger levels	
		PNG Standards for Drinking Water[b]	WHO Guidelines for Drinking Water Quality[c]	Site-specific trigger values[d]
				90th percentile
General Water Quality Parameters				
Total dissolved solids	mg/L	1,500	1,000	–
pH	–	6.5 to 9.2	–	–
Total suspended solids	mg/L	1,500	–	–
Turbidity	NTU	25	5	–
Metals and Metalloids (total)				
Aluminium	mg/L	–	0.02	0.047
Arsenic	mg/L	0.05	0.01	–
Cadmium	mg/L	0.01	0.003	–
Chromium, Total	mg/L	–	0.05	–
Copper	mg/L	1.5	2	–
Iron	mg/L	1	0.3	–
Manganese	mg/L	0.5	0.4	–
Mercury, inorganic	mg/L	0.001	0.006	–
Nickel	mg/L	–	0.07	–
Lead	mg/L	0.1	0.01	–
Selenium	mg/L	0.01	0.04	–
Silver	mg/L	0.05	–	–
Zinc	mg/L	15	3	–

[a] Applicable at AP7.

[b] Public Health (Drinking Water) Regulation 1984, Schedule 2

[c] WHO, 2017

[d] Based on background concentration measured in the Frieda River. Metals values are for total metals. Values may be updated following further pre-construction baseline monitoring. Adopted where background concentrations are higher than the PNG Standards for Drinking Water and the WHO Guidelines for Drinking Water Quality.

Table 12.3 Ambient water quality criteria – marine aquatic ecosystems[a]

Parameter	Units	Regulatory Criteria	Project trigger levels	
		PNG Schedule 1 Marine Aquatic Ecosystems[b]	PNG ECP Marine Aquatic Ecosystems[c]	ANZECC/ARMCANZ Trigger Values for Marine Water[e]
General Water Quality Parameters				
pH	–	–	Less than 0.2 pH unit change from normal pH	8.0 - 8.4
Total suspended solids	mg/L	–	Less than 10% change from background mean seasonal values	–
Turbidity	NTU	No alteration greater than 25 NTU from natural conditions	Less than 10% change from background mean seasonal values	1 - 20

Table 12.3 Ambient water quality criteria – marine aquatic ecosystems[a] (cont'd)

Parameter	Units	Regulatory Criteria	Project trigger levels	
		PNG Schedule 1 Marine Aquatic Ecosystems[b]	PNG ECP Marine Aquatic Ecosystems[c]	ANZECC/ARMCANZ Trigger Values for Marine Water[e]
Metals and Metalloids				
Aluminium	mg/L	–	–	0.024[f]
Arsenic	mg/L	0.05	0.05	–
Cadmium	mg/L	0.001	0.002	0.7
Chromium (VI)	mg/L	0.01	–	0.0044
Copper	mg/L	0.03	0.005	0.0013
Iron	mg/L	1.0 (in solution)	–	–
Manganese	mg/L	2.0 (in solution)	–	–
Mercury	mg/L	0.0002 (in solution)	0.0001	0.0001
Nickel	mg/L	1.0	0.015	0.007
Lead	mg/L	0.004	0.005	0.0044
Selenium	mg/L	0.01	0.07	–
Silver	mg/L	–	0.001	0.0014
Zinc	mg/L	5.0	0.05	0.15

[a] Applicable at the marine mixing zone boundary in Dakriro Bay.

[b] PNG Environment (Water Quality Guidelines) Regulation 2002, Schedule 1. Metal concentrations are for dissolved substances, passing through a nominal 0.45 µm filter.

[c] PNG Environmental Code of Practice (OEC, 2000).

[e] Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000), slightly to moderately disturbed system.

[f] Golding et al, 2015.

Table 12.4 IFC effluent guidelines[a]

Pollutants	Units	Guideline Value[b]
Total Suspended Solids	mg/L	50
pH	S.U.	6 to 9
COD	mg/L	150
BOD5	mg/L	50
Oil and Grease	mg/L	10
Arsenic	mg/L	0.1
Cadmium	mg/L	0.05
Chromium (VI)	mg/L	0.1
Copper	mg/L	0.3
Cyanide	mg/L	1
Cyanide (Free)	mg/L	0.1
Cyanide (weak acid dissociable)	mg/L	0.5
Iron (total)	mg/L	2.0
Lead	mg/L	0.2
Mercury	mg/L	0.002
Nickel	mg/L	0.5

Table 12.4 IFC effluent guidelines[a] (cont'd)

Pollutants	Units	Guideline Value[b]
Phenols	mg/L	0.5
Zinc	mg/L	0.5
Temperature	°C	<3°C differential

Note: Metals concentrations represent total metals

[a] Applicable at end-of pipe discharge points.

[b] IFC, 2007d

Monitoring of water and sediment quality during construction and operations will be undertaken at a range of other locations including Project-area streams, off-river waterbodies and at the ocean port to identify Project-related impacts as described above. Further monitoring in the Frieda and Sepik rivers will also be conducted in the first two years of operations to establish a relationship between dissolved copper and labile copper.

Aquatic Biology

Monitoring will be undertaken to identify aquatic biological impacts as a result of the Project to assess the success of management measures and identify areas where changes to management measures will limit risks to aquatic biology.

The aquatic biology monitoring program will include:

- Assessment of the abundance and diversity of aquatic biota including the presence/abundance of introduced species in watercourses downstream of the Project, as well as at reference sites. This will include survey sites on the Frieda and Sepik rivers and smaller tributaries.
- Metal concentrations in the tissues of aquatic biota to monitor metal bioaccumulation in comparison to the baseline data.
- Catches per unit effort of key fish species important from a resource use perspective.
- Downstream riverine and floodplain ecosystem condition.

Marine Biology

Marine biological monitoring will be undertaken to confirm predictions in the EIS with respect to potential impacts in Dakriro Bay associated with the construction and operation of the Vanimo Ocean Port, the export of concentrate and the discharge of excess filtrate water from the concentrate thickener. The marine biology monitoring program will include:

- Metal concentrations in the tissues of marine biota to monitor metal bioaccumulation in comparison to baseline data.
- Sediment deposition around the proposed Vanimo Ocean Port.
- Assessment of marine ecosystem condition near the proposed Vanimo Ocean Port and at reference sites away from Project influences.

Groundwater

Groundwater monitoring infrastructure is already in place around some parts of the mine and FRHEP area and, where required, monitoring of these locations will be carried out throughout the Project life. Additional monitoring locations may be required prior to the commencement of construction to establish baseline groundwater conditions where potential impact to groundwater values has been identified.

In addition, where existing monitoring locations will be disturbed by advancing mining activities, they will be progressively replaced in accordance with the Project groundwater monitoring commitments and requirements.

Prior to the commencement of mining and/or inundation of the ISF, a detailed groundwater monitoring plan will be developed and implemented to establish a baseline against which Project impacts may be assessed. This will include:

- Groundwater level and pressure monitoring around the open-pit and ISF from pre- to post-mining, to assess fluctuations in groundwater levels.
- Groundwater level and quality monitoring around the landfill at the mine area environmental waste management facility to assess groundwater quality and flow direction.
- Collation of open-pit groundwater inflow estimates.
- Periodic review of the monitoring data and comparison to predicted drawdown/water quality. Where supported by this data, revisions to the monitoring program and/or numerical groundwater modelling may be warranted.

Monitoring activities will continue for a suitable period post closure. The length of time over which this will be required will depend on the outcomes of future data assessment and evaluation programs during the operations phase and the agreed closure criteria to be described in the detailed mine closure plan.

Air Quality

Construction

Visual monitoring of dust emissions will occur when construction of the main road and pipeline is occurring close to villages. If visible dust emissions are observed being blown downwind of the works towards a sensitive receptor, or credible complaints regarding dust are received, additional mitigation measures may be applied. The effectiveness of management measures will also be observed and this information will be used to refine dust management as construction progresses along the infrastructure corridor.

Air quality impacts to sensitive receivers in the vicinity of other Project components are not predicted due to the remote location of the construction activities and/or effectiveness of management measures. Monitoring in these locations using low volume particulate monitors and/or dust deposition gauges may be undertaken in response to grievances, if received.

The operation of the existing meteorological monitoring stations will be continued to verify the baseline data used in the EIS and to provide information for future assessment of impacts or development of management programs.

Operation

No exceedances of ambient air quality criteria are predicted for the operational phase of the Project (see Section 8.8), therefore no ongoing routine ambient air quality monitoring is proposed. Air quality monitoring will be undertaken around the Vanimo Ocean Port at the start of operations to confirm the predictions of the EIS. This program will include monitoring of dust deposition and PM_{10} (particulate matter less than 10 µm in diameter), including particulate metal concentrations, at locations between the concentrate storage area and residences.

A stack emission sampling program for the incinerator is not proposed given the remote location of the mine area environmental waste management facility; however, a stack will be fitted with

suitable stack testing ports to allow safe and suitable access for flow and concentration measurements should monitoring requirements change.

If required, low volume particulate monitors will be used to investigate credible complaints regarding particulate levels downwind of operations activities.

General

Air emissions associated with all construction and operations activities will be managed through compliance with the EMMP and relevant sub-plans. These sub-plans will include procedures designed to meet the air quality objectives adopted for the Project and the environment permit conditions and will be implemented so that:

- The Project is conducted in a manner that limits the generation of air emissions.
- The effectiveness of the controls being implemented is monitored.
- Additional measures are implemented, where required, as determined by the monitoring program.
- A complaints management system is implemented so that identified incidents or complaints are dealt with through investigation and implementation of corrective treatments.

Noise and Vibration

Noise and vibration generated by construction and operations activities will be managed through compliance with the EMMPs and relevant sub-plans. These sub-plans will include procedures designed to meet the noise objectives adopted for the Project and the environment permit conditions. Procedures will include notification to communities that may be impacted by planned noisy activities and implementation of temporary safety exclusion zones where required (e.g., for blasting).

Background noise levels will be established through baseline noise monitoring at selected sensitive receptors along the infrastructure corridor and in the vicinity of the proposed Vanimo Ocean Port prior to construction. During construction, noise monitoring will be conducted at sensitive receivers in response to complaints and/or to verify noise levels associated with the construction of the main road, pipeline and Vanimo Ocean Port.

Vibration monitoring will be conducted where general vibration generating construction activities (e.g., compacting works) are carried out within 55 m of sensitive receptors.

Noise and vibration monitoring of blasting activities may be required at sensitive receivers in the vicinity of blasting activities required for the construction of the main road and pipeline. The monitoring program will be determined upon review of the proposed blast locations and design parameters.

Erosion and Sedimentation

Due to the high rainfall in the mine and FRHEP area, erosion and sediment control structures outside the immediate mining area will be inspected on a weekly basis (and potentially more than once a week during extreme rainfall events) to ensure that no material destabilisation, deterioration or greater-than-expected silt build up has occurred. Inspections will also be performed on areas that have not been permanently stabilised, at structural control measures and on construction entrances and exits to and from the work sites. Inspections of erosion and sediment control structures outside the mine and FRHEP area will take place following high rainfall events as required due to the lower rainfall in the lowland areas.

Visual inspection of watercourses and drainage paths will be undertaken weekly to determine the extent of sedimentation. More frequent inspections may be required if issues have been identified previously or in the event of an extreme rainfall event. Photographic monitoring points will be established at representative locations.

Soils and Rehabilitation

Stages of Monitoring

Monitoring throughout various stages of the Project's rehabilitation program will involve:

- **Comparison with preconstruction conditions and closure criteria.** Assessment of soil and revegetation parameters against baseline data and closure criteria will be undertaken by identifying vegetation that is not re-establishing and adopting specific measures to improve its sustainability.
- **Rehabilitation growth medium.** Trials with periodic monitoring will be conducted to investigate methods of creating suitable rehabilitation mediums. This may include using organic matter from wood chips produced from chipping felled trees and other wood waste generated during clearing operations.
- **Establishment of reference plots.** Permanent reference plots, representing both the major and minor habitat units that occur on areas to be disturbed, will be established in areas that will not be disturbed by the Project's activities. Their botanical composition will be quantified during preconstruction baseline surveys and as appropriate during operation. These reference plots will provide a continuous and consistent measure of vegetation changes over time in response to climatic conditions. Locations of permanent reference plots, and other monitoring plots that will be established, will be recorded using GPS, permanently marked to facilitate monitoring as required and cross-linked with flora and fauna management programs. Where practicable, monitoring plots will be situated away from villages.
- **Revegetation trials.** Trials and subsequent monitoring will be completed using a range of species such as nitrogen fixing tree species, shrubs and ground creepers to readily establish and introduce nitrogen into the soil, along with dropping leaf litter that decomposes. Trials will investigate the success of different revegetation methods such as hydroseeding, direct planting and natural regeneration.

Implementation of Rehabilitation Monitoring Program

The nature of monitoring activities, i.e., the task sequence, data review and improvements to monitoring, will be defined in a monitoring program to assist with rehabilitation efforts. This program will include relevant closure criteria and the following factors will be monitored:

- **Soil.** Physical and chemical characteristics such as surface stability (e.g., resistance to erosion), capacity to accept rainfall, nutrient status and ability to support plant growth will be monitored during and following rehabilitation activities and compared with pre-mining conditions.
- **Vegetation.** Plant abundance will be assessed in relation to stated targets twelve months after topsoil respreading or after seeding and at appropriate intervals until criteria are met. Performance against closure criteria will be determined by ecosystem function analysis or a similar system-based monitoring approach. Significant flora that has had to be planted will be monitored separately for survival and growth for a period of up to three years. Areas deficient in revegetation quality or quantity will be noted and analysed to determine the reason for poor

performance. Where necessary, the causes will be rectified, the site re-treated and appropriate adjustments made to rehabilitation planning.

- **Landforms and disturbed areas.** Monitoring erosion rates on constructed landforms and in disturbance areas will be undertaken immediately following rehabilitation activities and then on an annual basis. Assessment will include a comparison of pre- and post-disturbance erosion rates.

Terrestrial Biodiversity

A terrestrial biodiversity monitoring program will be implemented, aimed at demonstrating that the values of the Terrestrial Biodiversity Study Area have been maintained. This program will include:

- Monitoring ground disturbance and vegetation clearance during construction.
- Annual sampling of forest condition and biodiversity at Project road and facility edges following construction.
- Biennial analysis of imagery to monitor habitat cover and condition in order to determine the extent, if any, of indirect effects from increased access and the extent, if any, of fires.
- Annual monitoring of amphibious fauna in streams and adjoining forests in order to provide an integrated measure of ecological health of streams and riparian vegetation, and demonstration of the persistence of many of the species new to science.
- Annual aerial surveys of waterbirds and flying fox colonies in the lowland zone in order to determine the abundance of migratory and/or congregatory species.

Pest, weeds and pathogen monitoring will also be conducted and will include:

- Rodent monitoring at major infrastructure sites to ensure that exotic pest rodents are detected early and appropriate eradication measures are implemented. Where exotic rodent pests are detected, samples will be collected for disease screening for major pathogens.
- Quarterly monitoring of areas with high potential for susceptibility to weed invasion, such as along roadsides, recently cleared areas and newly rehabilitated areas, at regular intervals.
- Recording the use of weed and pest control techniques to gauge the effectiveness of suppression techniques against monitoring data.

The biodiversity monitoring program will be reviewed every three years. For aspects where there is no evidence of change, monitoring frequency or scope may be modified.

Social

Management measures to be undertaken in respect of social aspects are described and discussed in Chapter 9. Monitoring that will be undertaken to assess the effectiveness of the management measures will include:

- **Employment and income**. This will include monitoring the number of jobs by employer by employment zone, person/months of employment by employment zone and gross income by employment zone.
- **Business development**. This will include the number of local/landowner businesses established by type and the number of contracts and value let to local/landowner businesses, provincial businesses, national businesses and international businesses.

- **Local community well-being**. This will include monitoring of parameters relating to the well-being of the local community, such as:
  - Housing numbers by standard.
  - Percentage of housing with access to improved water/sanitation.
  - Percentage of housing with access to improved lighting by type.
  - Status of under five year old health.
  - Status of maternal health.
  - Status of access to medical service provision.
  - Incidence of communicable disease by village.
  - Status of school attendance by level.
  - Teacher attendance and satisfaction with institutional support.
  - Adequacy of resource availability by school.
  - Adequacy of school physical infrastructure.
  - Villager satisfaction with information provision.
  - Villager satisfaction with grievance management process.
  - Status of livelihood restoration by household by village.
- **Regional community opportunities**. This will include monitoring for non-Project related business opportunities and growth, such as:
  - Travel time and cost to next level administrative centre.
  - Level of access to mains power.
  - Business connections/use of mains power.
  - Agricultural enterprise production level by type.
  - Logging activity by area.
  - Grievances received and resolved by type and community.
- **Population**. This will include monitoring population at villages around the mine, Green River, Hotmin and along the road corridor.

Summary of Monitoring Requirements

Aspects proposed for monitoring are summarised in Table 12.5 with an indication of the proposed frequency of monitoring. In most cases, monitoring will commence during construction. Attachment 1 presents a compilation of environmental management commitments from the environmental impact assessment chapters. Further details with regards to monitoring is provided in Attachment 2.

Table 12.5 Summary of monitoring requirements

Aspect	Indicative Frequency	
	Construction	**Operations**
Surface Water		
Drinking water quality of representative water sources used for drinking purposes	Quarterly	Quarterly
Water quality of freshwater and marine aquatic ecosystems	Weekly to quarterly (depending on location)	Monthly to quarterly (depending on location)
Sediment quality within freshwater and marine aquatic ecosystems	Every 3 to 6 months (depending on location)	Every 3 to 6 months (depending on location)

Table 12.5 Summary of monitoring requirements (cont'd)

Aspect	Indicative Frequency	
	Construction	**Operations**
Aquatic Biology		
Diversity and abundance of aquatic biota	Annually	Annually for the first 5 years of operation, then every 3 years
Metals concentrations in tissues of aquatic biota	Annually	Annually
Catch per unit effort of key fish species	Annually	Annually for the first 5 years of operation, then every 3 years
Downstream riverine and floodplain ecosystem condition	Annually	Annually for the first 5 years of operation, then every 3 years
Marine Biology		
Sediment deposition in Dakriro Bay	Monthly	
Metals concentrations in tissues of marine biota	Annually	Annually
Nearshore marine ecosystem condition	Annually	Annually for the first 5 years of operation, then every 3 years
Groundwater		
Levels and pressures	Monthly	Monthly
Physico-chemical parameters	Monthly	Monthly
Sampling for laboratory analysis – comprehensive suite of analytes	Annually	Annually
Sampling for laboratory analysis – restricted suite of analytes	Quarterly	Quarterly
Air Quality and Meteorology		
Dust (visual)	During construction of the main access road and pipeline	
Dust (deposition gauges)	In response to grievances	Monthly at Vanimo Ocean Port In response to grievances
PM_{10}	In response to grievances	Monthly at Vanimo Ocean Port In response to grievances
Meteorological monitoring	Ongoing	Ongoing
Noise and Vibration		
Noise	At selected sensitive receptors during construction of the main road, pipeline and Vanimo Port and in response to grievances	In response to grievances
Vibration	Where general vibration generating construction activities are carried out within 55 m of sensitive receptors	In response to grievances
Erosion		
Erosion and sediment control structures	Weekly during disturbance activities	Weekly during disturbance activities
Watercourses and drainage paths	Weekly until area has stabilised, every 3 months thereafter.	Weekly until area has stabilised, every 3 months thereafter.

Table 12.5 Summary of monitoring requirements (cont'd)

Aspect	Indicative Frequency	
	Construction	Operations
Rehabilitation		
Permanent reference plots – quantify vegetation composition	Periodically	Periodically
Physical and chemical characteristics of soil	During and following rehabilitation activities	During and following rehabilitation activities
Plant abundance	Six months after topsoil respreading or after seeding	Six months after topsoil respreading or after seeding
Species health, richness, abundance and vegetation cover	Every six months for 24 months after topsoil respreading and seeding	Every six months for 24 months after topsoil respreading and seeding
Erosion rates on constructed landforms and in disturbance areas	Following rehabilitation activities then annually	Following rehabilitation activities then annually
Terrestrial Biodiversity		
Biodiversity – imagery analysis of the Project site	Every two years	Every four years
Frogs in streams and adjoining forests	Annually	Annually for the first 5 years of operation, then every 3 years
Forest condition	Annually	Annually for the first 5 years of operation, then every 3 years
Waterbirds and flying fox colonies in the study area lowland zone	Annually	Annually for the first 5 years of operation, then every 3 years
Social		
Employment and income	Every 4 months	Annually for the first 5 years of operation, then every 3 years
Business development	Every 4 months	Annually for the first 5 years of operation, then every 3 years
Local community well-being	Every 4 months to annually, depending on parameter	Annually for the first 5 years of operation, then every 3 years
Regional community opportunities	Every 4 months to annually, depending on parameter	Annually for the first 5 years of operation, then every 3 years
Population trends	Every 6 months to annually, depending on location	Annually for the first 5 years of operation, then every 3 years

In addition to the routine monitoring program, in the event that the emergency response plan is initiated, a full review of its efficacy will be conducted on close-out of the emergency, including identifying areas for improvement.

12.6.4 Auditing and Reviewing

The Project's success in achieving the environmental and social management objectives and targets will be reviewed annually during operation. The EMMPs, SMPs and the procedures outlined within them will be regularly reviewed during construction and operation to ensure that:

- Project activities are undertaken in compliance with statutory obligations.
- The environmental and social objectives of the Project are achieved.
- The environmental and social management measures are effectively implemented.
- A system of continuous improvement is established.

- Further information is incorporated into the plan as it is obtained and evaluated.

The frequency of updates to the EMMPs and SMPs will be defined in the environment permit conditions.

Audits will be undertaken on a regular basis against relevant standards and criteria to ensure compliance with the environmental management procedures and environment permit conditions and continual improvement of the management systems and processes for the Project.

12.6.5 Reporting

Internal Reporting

Results from monitoring activities will be recorded in regular reports (e.g., quarterly or annually) prepared by in-house staff or suitably qualified and experienced third parties. These reports will be distributed internally as required to report on compliance of activities with conditions of approval and performance against monitoring criteria. Reports will contain data to assess the effectiveness of mitigation measures and will assist in identifying areas where environmental management measures need to be improved. Monitoring reports will generally contain:

- Introduction.
- Legislative framework and standards.
- Monitoring criteria.
- Monitoring methods.
- Monitoring results.
- Corrective action.

Results from monitoring activities will feed into formal environmental and sustainability reporting to various corporate entities.

External Reporting

Monitoring reports will be submitted to CEPA and other regulatory authorities, depending on the environment permit conditions. Compliance with the EMMPs will be described in these reports as well as recommendations for corrective action. In PNG, this is typically in the form of an Annual Environment Report.

An independently verified Sustainability Report is published by PanAust on an annual basis that meets the Global Reporting Initiative G4 Sustainability Reporting Guidelines. PanAust's Sustainability Report will incorporate FRL's performance.

FRL will formally disclose the results of additional assessments and monitoring activities to relevant stakeholders on a regular basis. This will include annual 'river health cards' that present the results of the downriver environmental monitoring program in a straightforward format readily understood by local villagers. These annual report cards will provide information on aspects such as:

- Surface water quality.
- Drinking water quality.
- Edibility of aquatic resources.
- Community feedback received.

FRL will establish an independent advisory committee to assist FRL in addressing the environmental and related social impacts of its mining activities upon the local and downstream communities. The committee will be established prior to the commencement of construction and

will comprise prominent PNG citizens and local and international technical specialists. The committee will provide direction and technical oversight for monitoring and investigations of the environmental and social impacts in the mine area and downstream and will improve public understanding of the Project's impacts and independently review FRL's environmental performance and accountability. The findings of the committee will routinely be made public.