FRIEDA RIVER

Frieda River Limited
Sepik Development Project
Environmental Impact Statement

Appendix 3a – Frieda River Copper-Gold Project Conceptual Mine Closure Plan

SDP-6-G-00-01-T-003-011

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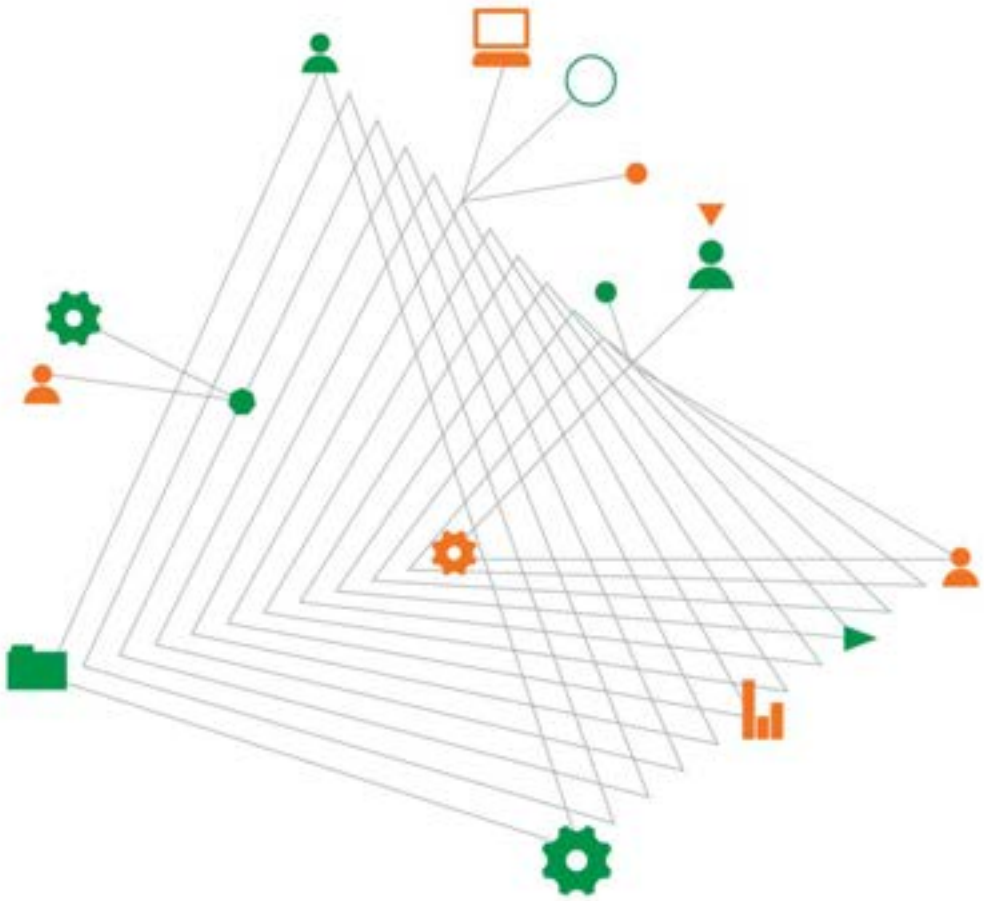
A TETRA TECH COMPANY

Frieda River Limited

Frieda River Copper-Gold Project
Conceptual Mine Closure Plan

18 September 2018



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Prepared for Frieda River Limited

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Quality Information

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1. INTRODUCTION

1.1 Background

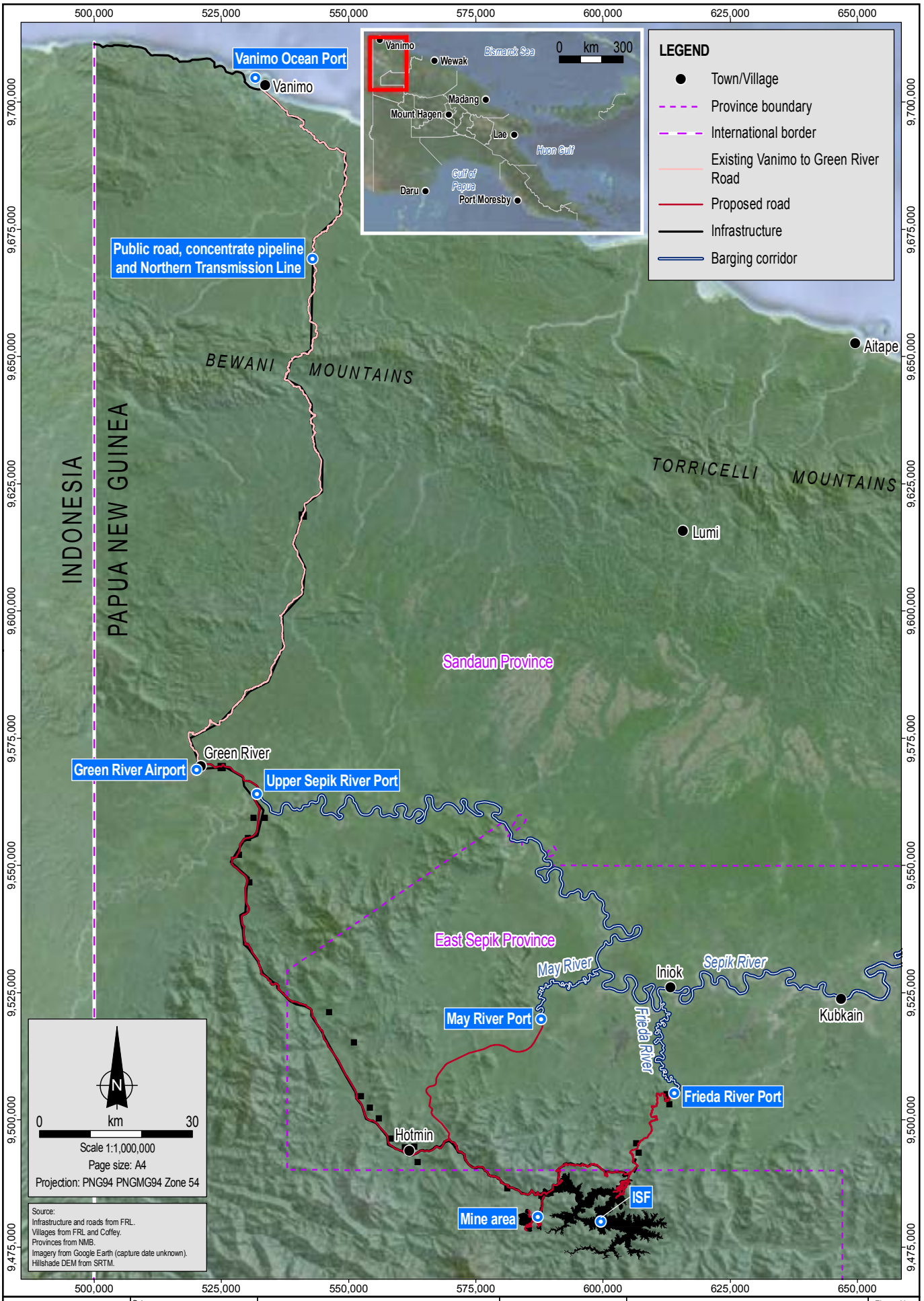
Frieda River Limited (FRL) is assessing the feasibility of the Sepik Development Project in the Sandaun and East Sepik provinces of Papua New Guinea (PNG) (see Figure 1.1). The Sepik Development Project is underpinned by the Frieda River Copper-Gold Project (FRCGP), which seeks to develop the Horse-Ivaal-Trukai, Ekwai and Koki (HITEK) porphyry copper-gold deposits, which contain an estimated total combined Measured, Indicated and Inferred Mineral Resource of over 2.6 billion tonnes at an average grade of 0.44% copper and 0.23 grams per tonne gold.

The FRCGP is one of the largest known undeveloped copper resources in the world. Copper mineralisation was first identified at Frieda River in 1966/67 and the long history of exploration and study activities undertaken by several companies has generated a considerable body of information.

The FRCGP mine area is located in the northern foothills of the Central Range of the New Guinea Highlands in Sandaun Province. It lies in a remote area approximately 200 kilometres (km) from the northern coast and 50 km from the Sepik River. The area is characterised by steep terrain, very high rainfall, low population density and a near-absence of infrastructure such as road, power and communication networks. The supporting infrastructure corridor traverses generally northwest from the mine area through the Saniap, Usake and Upper May river catchments in the East Sepik Province and then generally north through the lowlands of the Sepik River floodplain in Sandaun Province, before traversing over the Bewani Mountains and the northern coastal plain to Vanimo on the northern coast of PNG (see Figure 1.1).

The FRCGP will comprise a large-scale conventional open-pit mine operation feeding ore to a comminution and flotation process plant producing a copper-gold concentrate for export to custom smelters. Mining inventory comprises 1,500 Mt of mill feed. Ore will be processed at an average rate of approximately 45 million tonnes per year (Mt/y) over a 33-year mine life. The average annual copper-gold concentrate production will be 735,000 wet tonnes and the average annual metal in concentrate production will be 175,000 tonnes (t) copper and 230,000 ounces (oz) gold. The copper-gold concentrate will be transported from the process plant via a 325 km-long concentrate pipeline located within the infrastructure corridor to a concentrate storage and export facility located at the Vanimo Ocean Port. The mine area includes the open-pit, process plant, mine access roads, site accommodation village and other ancillary infrastructure as shown in Figure 1.2.

Approximately 2.9 billion tonnes of tailings and waste rock will be produced over the life of the mine. Mine waste rock and tailings will be deposited subaqueously in an engineered integrated storage facility (ISF) located in the Frieda River catchment northeast of the open-pit (see Figure 1.2). The ISF will store water for the hydroelectric power facility, which will provide the power supply to the FRCGP. The ISF and hydroelectric power facility are part of the Frieda River Hydroelectric Project (FRHEP). Excess power from the hydroelectric power facility will be made available for a power distributor to purchase and on sell to PNG users or export to Indonesia. Construction of the Northern Transmission Line along the infrastructure corridor to the north coast of PNG is termed the Sepik Power Grid Project (SPGP). The main access route to mine, along with a regional airport at Green River and upgraded Vanimo port facilities is known as the Sepik Infrastructure Project (SIP).



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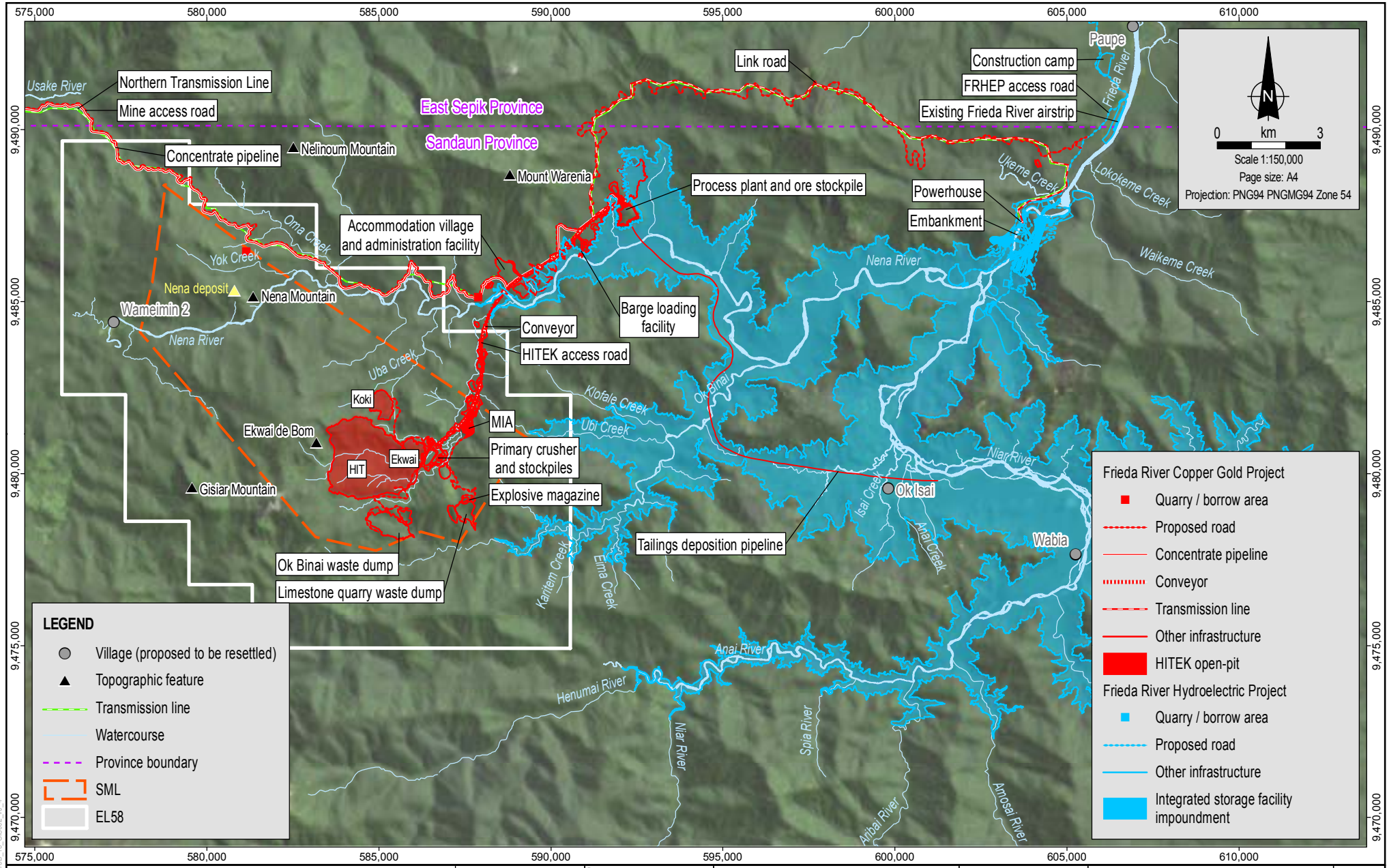
coffey A TETRA TECH COMPANY	Date: 15.08.2018 Project: 754-ENAUABTF11575B File Name: 11575_18_F01.01_GIS	Frieda River Limited Sepik Development Project	FRIEDA RIVER	Sepik Development Project overview	Figure No: 1.1



Source:
Infrastructure, roads and tenements from FRL.
Villages, topographic features, watercourses and water bodies from FRL and Coffey.
Provinces from NMB.
Landsat satellite imagery from FRL (capture date unknown).
Hillshade DEM from SRTM.

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File Name: 11575_18_F01.02_GIS

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Sepik Development Project

FRIEDA RIVER

Mine and ISF area

Figure No: **1.2**

MXD Reference: 11576B_18_GIS002_v0_4

This plan covers the decommissioning and closure of the FRCGP infrastructure. The infrastructure associated with the operation of the FRHEP is covered under a separate closure plan titled Frieda River Hydroelectric Project Conceptual Closure Plan.

1.2 Scope

The scope of this document covers infrastructure and developments associated with the FRCGP. Components of the FRCGP include:

- The HITEK open-pit and quarries.
- Mine infrastructure including the ore and waste rock primary crushers, ROM pad and stockpiles, overland conveyor system, explosives magazine area, raw water pipeline and supporting workshops, buildings and fuel storages.
- Waste management infrastructure and facilities including the Ok Binai waste dump, limestone quarry waste dump, tailings pipeline and waste barging facilities.
- Linear infrastructure including the concentrate pipeline and mine access roads.
- Ancillary infrastructure including the accommodation village and communication facilities.
- Export facilities at Vanimo including concentrate filter plant, concentrate export facility and Vanimo infrastructure area.
- Community infrastructure and development programs associated with FRCGP.

Decommissioning and closure of the FRHEP is covered under a separate closure plan (Coffey, 2018). A number of infrastructure components of the FRCGP are shared with the FRHEP (e.g., roads and transmission line towers). These components are discussed in terms of handover of liability, but not specific closure actions.

The proposed layout is shown in figures 1.1 and 1.2; however, this may change as planning for, and development of, the FRCGP progresses. This and subsequent mine closure plans will be updated to reflect material project changes as required.

This plan covers both rehabilitation (and related activities) that will occur progressively throughout the mine life, and the decommissioning and rehabilitation that will occur at the end of mine life. To this effect, ‘closure’ refers to the process by which the FRCGP reaches its final state following the cessation of mining and processing.

1.3 Purpose of this Document

This Conceptual Mine Closure Plan serves as a planning tool to assist FRL in the eventual closure of the infrastructure and developments associated with the FRCGP. Specifically, the purpose of this plan is to:

- Define closure objectives in relation to the FRCGP and provide a clear outline of how these will be met.
- Identify the site-specific, key environmental and social issues relevant to closure planning.
- Document FRL’s stakeholder consultation plan in relation to mine closure.
- Identify the completion criteria for closure that are specified in the relevant documents, policies and guidelines.
- Provide the basis for the ongoing review of closure concepts and closure costs provisioning.

This plan has been prepared in accordance with the PanAust Group's Closure Standard (PAA, 2014), as well as:

- PanAust Group's policies and other standards.
- Recognised international guidelines such as the International Council for Mining and Metals sustainable development framework (ICMM, 2015).
- Papua New Guinea's regulatory framework, including the draft Mining Project Closure Policy (MRA and DMPGM, 2015).

1.4 Definitions

Key steps in relation to mine closure process are described below and shown in Figure 1.3.

Progressive rehabilitation. The process of rehabilitating those portions of the disturbed sites that are no longer necessary for the immediate operating requirements of the mine to reach the agreed post-mining land use. Progressive rehabilitation would be expected to occur during operations (i.e., years 1 to 33).

Decommissioning. Decommissioning begins at the cessation of mining and mineral production and will involve demolition and disposal of all unwanted infrastructure and services. Personnel will comprise a smaller contractor-oriented workforce shutting down the facility. Closure monitoring will be implemented during decommissioning. Decommissioning is expected to occur during years 34 and 35.

Post closure monitoring and maintenance. This involves evaluating monitoring data and other evidence, in consultation with regulators and relevant stakeholders, to determine if the objectives and closure criteria have been met. Some ongoing rehabilitation works and maintenance will also occur. Post closure monitoring and maintenance is expected to occur until completion criteria are met.

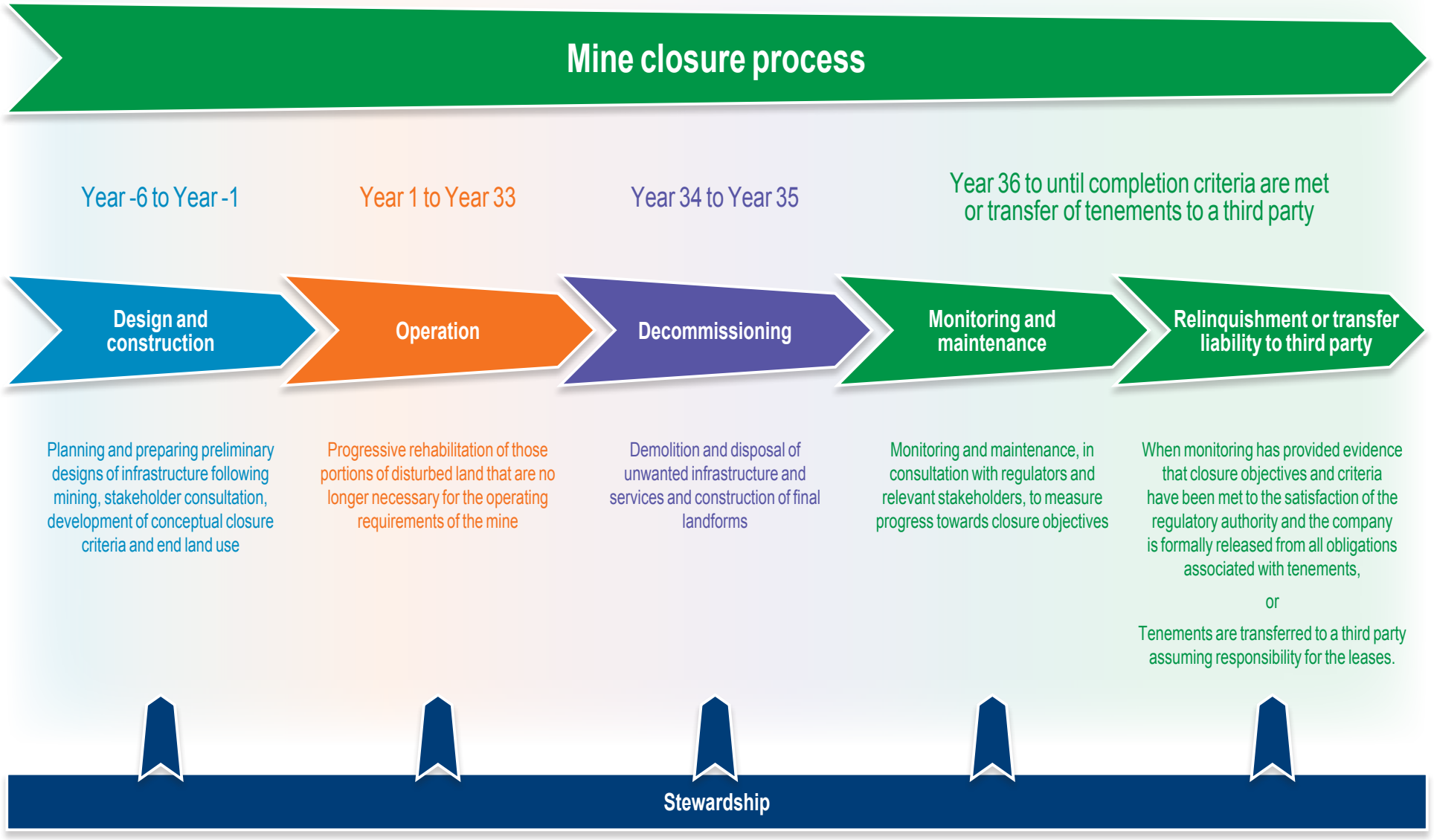
Relinquishment. When monitoring has provided evidence that the objectives and closure criteria have been met to the satisfaction of the regulatory authority, the company is formally released from all obligations with respect to associated tenements, with the regulators or a third party assuming responsibility for the leases.

Closure. Is the process by which the project reaches its final state following the cessation of mining and processing and refers to the entire process from progressive rehabilitation, decommissioning, post closure monitoring and maintenance, and relinquishment.

Stewardship. The care and management of a facility through its life cycle (from exploration through mining to closure) including the infrastructure used during operations and following relinquishment.

Disturbance area. Area of land that will be occupied by the Project infrastructure and a buffer to allow for construction and maintenance activities. Structures may be in place for a temporary or permanent time frame.

Mine closure process



coffey A TETRA TECH COMPANY	Date: 01.06.2018 Project: 754-ENAUABTF11575B File Name: 11575_18_F01.04_GRA	Frieda River Limited Sepik Development Project	FRIEDA RIVER	Mine closure process	Figure No: 1.3

AI Reference: 11575_18_GRA001.ai_1

2. REGULATORY AND POLICY FRAMEWORK

The following section provides a summary of PNG legislation and policy, relevant PanAust closure standards, and other frameworks relevant to rehabilitation and mine closure planning for the FRCGP.

2.1 Legislation and Policy of PNG

The Independent State of Papua New Guinea promotes the sustainable development of its mineral resources through various policies. This is supported by a legislative and policy framework, which ensures that approved developments assess, reduce and manage residual environmental and social impacts. It is a government priority and constitutional requirement to ensure that the people of PNG benefit from the development of their resources within a sustainable, environmentally responsible and socially acceptable manner.

The environmental and socio-economic aspects of the FRCGP are regulated primarily by the *Mining Act 1992* (Mining Act) and the *Environment Act 2000* (Environment Act).

The Mining Act is presently the principal policy and regulatory document governing the mining industry in PNG. The Mining Act vests ownership of all minerals in or below the surface of land or under the sea with the national government, and governs the exploration, development, processing and transport of minerals. The rights to explore for, mine and sell mineral resources are granted in the form of tenements. The FRCGP is likely to operate under a Special Mining Lease (SML), with Leases for Mining Purposes (LMPs) required for the ISF and other mine infrastructure, Mining Easements (ME) required for private roads and a mining lease for the FRHEP. SML, LMP, ME and ME tenements granted under the provisions of the Mining Act will revert back to the State on relinquishment.

In November 2000, the PNG Government approved the Environment Act, which was implemented with its associated regulations in January 2004. The FRCGP has been deemed a Level 3 activity under the Environment (Prescribed Activities) Regulation 2002, sub-category 14.1, 14.2, 17.1, 17.2, 19.1 and 19.2 for which an environmental impact statement (EIS) is required to be submitted to the Conservation Environment Protection Authority (CEPA).

The existing PNG Mine Closure Policy and Guidelines (2005) primarily focus on the administrative and financial requirements to achieve key closure objectives, including:

- Minimisation of negative environmental or social impacts from mining activities during the mine life and elimination, where possible, of negative impacts after mining operations cease.
- Ensuring that as many benefits as possible from mining are sustained beyond the life of a mine.

In addition, the PNG Mining Project Closure Policy (MRA and DMPGM, 2015)[1] is intended to operate in conjunction with the Mining Act and *Mining (Safety) Act 1977*, Environment Act and the Mineral Policy Handbook (2012) (which summarises the mining policies for the country). The policy states that during the feasibility phase of a project the tenement holder shall:

- Ensure that the mining project closure planning will be an integral component of mining project planning.

[1] Policy in draft form.

- Consult and involve all levels of governments and other relevant stakeholders in the mining project closure planning.
- Capture the sustainable development, ownership and transfer of mining project facilities in the mining project closure planning.
- Develop a Conceptual Mining Project Closure Plan during a mining project's environmental impact assessment process within the feasibility stages of the mining project. The Conceptual Mining Project Closure Plan shall identify broader objectives, principles, policies, procedures, organisational arrangements, timeframe and an estimated cost of implementing closure obligations as prescribed.
- Submit a Conceptual Mining Project Closure Plan to MRA and CEPA (who is responsible for environment matters during the application for an environment permit)[2].
- Be responsible for putting in place adequate financial security to meet its mining project closure obligations stated in its Conceptual Mining Project Closure Plan.

Supplementary to legislation, policy and regulation documents, the PNG mining industry environmental code of practice (ECP) (OEC, 2000) addresses the issue of rehabilitation and mine decommissioning. The focus of the code is on the physical aspects of closure, such as building removal, waste rock dump seepage, safety aspects of open-pits and underground workings, and the geotechnical stability of tailings impoundments.

Although there is no single comprehensive legal framework in PNG to deal with all aspects of mine closure, the PNG Government, through the Environmental Monitoring Branch of the Mineral Resources Authority, is actively involved in the mine closure planning process as well as ongoing monitoring during closure. In addition to the previously mentioned legislation, the following legislation needs to be considered in closure planning:

- *Explosives Act 1953*.
- *Industrial Safety, Health and Welfare Act 1961*.
- *National Cultural Property (Preservation) Act 1965*.
- *Building Act 1971*.
- *Road Maintenance Act 1971*.
- *Conservation Areas Act 1978*.
- *Prevention of Pollution at Sea Act 1979*.
- *National Parks Act 1982*.
- *Physical Planning Act 1989*.
- *Water Supply and Sewerage Act 1996*.

The following regulations also need to be considered:

- Inflammable Liquid Act and Inflammable Liquid Regulation 1953.
- Industrial Safety, Health and Welfare Regulation 1961.
- Public Health (Drinking Water) Regulation 1984.
- Building Regulation 1994.
- Environment (Procedures) Regulation 2002.
- Environment (Permits and Transitional) Regulation 2002.
- Environment (Prescribed Activities) Regulation 2002.
- Environment (Water Quality Guidelines) Regulations 2002.

[2] In consideration of the Mining Project Closure Policy (currently in draft form), FRL proposes that the submission of the Frieda River Copper-Gold Project Conceptual Mine Closure Plan will occur at the time of submission of the EIS. Additional requirements, such as estimated costs, will be included in subsequent iterations of the plan.

2.2 PanAust Group Sustainability Framework

The PanAust Group Vision and Values, and Sustainability Policy outline the company's commitment to preserving and enhancing the environmental, social, technical and financial elements of the business. Fourteen Sustainability Management Standards relating to leadership, risk management, health and safety, training, environment, stakeholder engagement and community have been developed to ensure consistent sustainability-related outcomes across the business.

Sustainability forms part of the Executive Management Team's five-year plan and their critical tasks. The General Manager Human Resources and Risk Management facilitates annual Risk and Sustainability Workshops with key management and operational and sustainability support staff from across the PanAust Group to drive company-wide alignment with PanAust's approach to sustainability.

PanAust measures its sustainability performance against international standards and commissions independent audits based on the Equator Principles and the International Finance Corporation's Policy on Social and Environmental Sustainability. PanAust uses an Enterprise Risk Management process to identify all key material risks and audits and/or reviews against those risks are carried out regularly. Through this process gaps are identified and risk management plans are developed and implemented.

International guidelines and standards that PanAust is aligned with include:

- 'Enduring Value – The Australian Minerals Industry Framework for Sustainable Development', which PanAust is a signatory to as an associate member of the Minerals Council of Australia (MCA). The Enduring Value framework commits companies to upholding fundamental human rights and respecting the cultures, customs and values of people affected by their activities.
- International Council on Mining and Metals policy on climate change.
- International Cyanide Management Code which promotes the responsible use of cyanide in gold mining and which PanAust is a signatory to (although this code is not relevant to the FRCGP as no cyanide will be used in the processing of ore).
- Global Reporting Initiative (GRI) which PanAust reports against. In 2017, PanAust produced its ninth annual Sustainability Report.

2.3 PanAust Group Closure Standard

The PanAust Group Closure Standard (hereafter referred to as the Standard) establishes guidelines for planning and implementing closure processes, provides guidance involved in closure processes and informs areas of mine planning and operation.

The intent of the Standard is to develop and maintain operational activities that have closure outcomes to a leading international standard with the ultimate goal of custodial transfer (i.e., relinquishment) once the site has been rehabilitated. The Standard is intended to provide a methodology for working cooperatively with all stakeholders including (but not limited to) local communities, employees and Government officials to ensure that PanAust's projects are closed in accordance with all relevant national laws and regulations.

The Standard prescribes that closure planning and costings be incorporated into exploration activities and feasibility studies and continue until the operation is finally closed, and the land and all responsibility and liability affected by the operation fully relinquished. As part of this process, key closure risks shall be identified within the exploration phase, with the level of detail and understanding of the issues increasing through mine development so that closure planning

remains aligned with mine operational plans. Closure planning shall become more detailed over the life of mine through deliberate closure-oriented studies such as baseline studies and impact assessments, field rehabilitation trialling, water flow, quality, erosive modelling and community consultation.

Guiding Closure Principles defined within the Standard are that:

I. Closure planning shall incorporate all phases of the life of the project, starting at exploration and continuing through to post-closure phase.
II. Mine closure planning shall be based on good corporate governance and comply with all legal and other corporate requirements.
III. Plans shall be incorporated into long-term business planning to reduce cost and liability.
IV. Adequate provision for closure implementation shall be allocated and reforecast annually to ensure sufficient budget is allocated for effective closure implementation.
V. Effective and transparent stakeholder engagement shall be undertaken in a timely manner and throughout all phases of the closure planning process.
VI. Closure planning shall integrate sustainable development considerations and aim to provide positive and measurable legacies for the community and environment post-closure.
VII. Post-closure land uses will be agreed with key stakeholders and implemented progressively during the operation phase to minimise ongoing post-closure monitoring and maintenance requirements and costs.
VIII. Closure planning shall adopt an early risk-based approach and be identified as a key mine planning and decision making tool throughout the life of the project.
IX. Closure plans shall remain live documents as part of an integrated mine closure planning process that can respond to changes as needs be.
X. The ultimate goal of the Closure Plan is to create conditions to allow for the transfer of land ownership, to a succeeding custodian based on an agreed set of completion criteria.

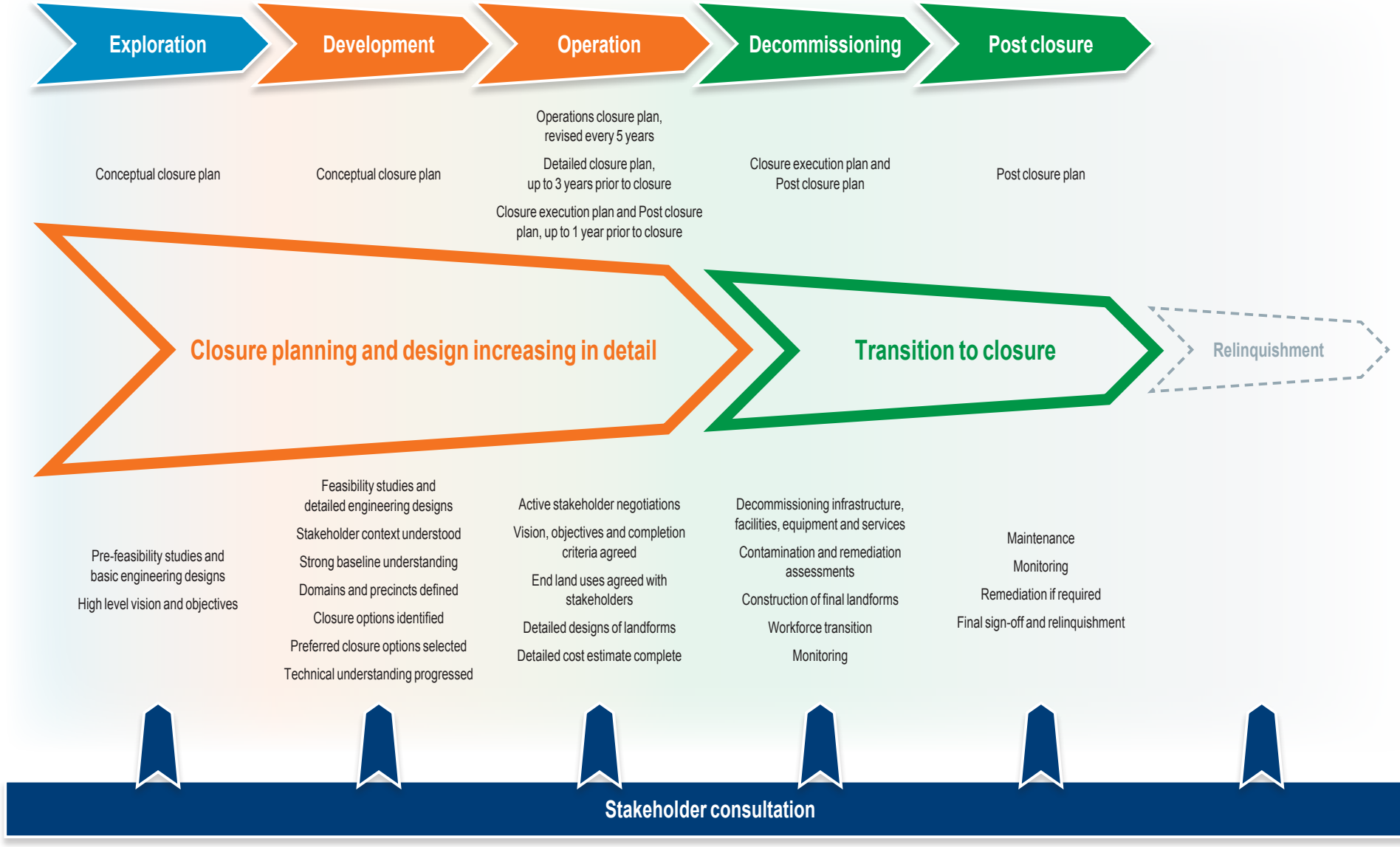
A schematic of PanAust's closure planning framework for the project is shown in Figure 2.1.

2.4 Guidelines and Performance Standards

2.4.1 International Standards

Large international projects are frequently assessed within the context of the Equator Principles (EPFI, 2006), which were developed in 2003 as an international banking industry framework to determine the environmental and social risks of project financing and are commonly referred to as 'the guidelines'. The guidelines provide a framework for financial institutions to assess the environmental and social impacts, the management of impacts and the risks associated with the projects that they fund, the underlying premise being that financial institutions will provide loans to projects that have met International Finance Corporation (IFC) requirements (i.e., IFC performance standards and environment, health and safety (EHS) guidelines) with respect to environmental and social aspects.

The EHS guidelines, which are technical reference documents describing examples of good international industry practice, address matters such as environment, occupational health and safety, community health and safety, and construction and decommissioning (IFC, 2012). Specific industry sector (including mining) guidelines are also available (IFC, 2007) and these describe specific management practices in relation to issues such as water use and quality, wastes, hazardous materials, land use and biodiversity, air quality, noise and vibration, energy use and visual impact.



	coffey A TETRA TECH COMPANY	Date: 16.08.2018 Project: 754-ENAUABTF11575B File Name: 11575_18_F02.01_GRA	Frieda River Limited Sepik Development Project	FRIEDA RIVER	Closure planning framework	Figure No: 2.1

AI Reference: 11575_18_GRA002.ai_2

FRL has used the requirements of the performance standards and EHS guidelines to guide closure planning for the FRCGP.

2.4.2 International Council of Mining and Metals

PanAust is a signatory to the International Council on Mining and Metals (ICMM) Sustainable Development Framework. The framework comprises three elements: a set of ten principles (including supporting position statements), public reporting and independent assurance.

The ten principles aim to ensure that minerals projects continually improve sustainable development performance. While all of the principles impact on mine closure planning and procedures to some degree, principle six – to seek continual improvement of environmental performance – provides specific implementation guidance about mine closure, as follows:

- Assess the positive and negative, the direct and indirect, and the cumulative environmental impacts of new projects – from exploration through closure.
- Implement an environmental management system focused on continual improvement to review, prevent, mitigate or ameliorate adverse environmental impacts.
- Rehabilitate land disturbed or land occupied by operations in accordance with appropriate post-mining land uses.
- Provide for safe storage and disposal of residual wastes and process residues.
- Design and plan all operations so that adequate resources are available to meet the closure requirements of all operations.

The principles outline the mining industry's global commitment to:

- Manage social, health, safety, environmental and economic issues in order to deliver sustainable shareholder value.
- Improve its performance in managing these issues.
- Publicly report the industry's progress in doing so.

In addition to the ten sustainability principles, ICMM has developed a toolkit for planning for integrated mine closure (ICMM, 2008b) that provides practical guidance for sustainable mine closure. The document provides a suite of tools to formulate well-considered decisions when planning for closure, and uses a risk- and opportunity-based approach through the iterative process of preparing for planned closure.

2.4.3 Enduring Value

To give practical and operational effect to the ICMM commitments, the Minerals Council of Australia (MCA) (of which PanAust is an associate member) developed *Enduring Value – The Australian Minerals Industry Framework for Sustainable Development*. Enduring Value is designed to assist minerals sector managers to implement the sector's commitment in a practical and operational manner that is targeted at the site level (MCA, 2005).

Enduring Value sets out ten sustainable development principles that aim to ensure that "investments in mineral projects are financially profitable, technically appropriate, environmentally sound and socially responsible" (MCA, 2005).

2.4.4 ANZMEC and MCA Strategic Framework for Mine Closure

The Australian and New Zealand Minerals and Energy Council (ANZMEC) and MCA jointly developed a strategic framework for mine closure (ANZMEC and MCA, 2000). The framework is

designed to provide a broadly consistent approach to mine closure across the various Australian jurisdictions and is structured around a set of objectives and principles grouped under six key areas:

- Stakeholder involvement.
- Planning.
- Financial provision.
- Implementation.
- Standards.
- Relinquishment.

This Conceptual Mine Closure Plan draws upon the leading-practice principles outlined in the ANZMEC and MCA strategic framework.

2.4.5 Leading Practice Sustainable Development Management

This plan has also considered the relevant aspects of the following Australian best practice guidelines developed in a booklet series on leading practice sustainable development management by the Australian Government:

- Tailings management (DITR, 2016) – addresses tailings management through the life of a project including planning, design, operation and closure of tailings storage facilities.
- Preventing acid and metalliferous drainage (DIIS, 2016e) – addresses management issues related to the environmental impacts and remediation of acid and metalliferous drainage in the mining industry.
- Biodiversity management (DIIS, 2016a) – addresses the broad issue of biodiversity management for mining operations, including environment protection and conservation legislation, flora and fauna and environmental offsets.
- Mine closure (DIIS, 2016c) – provides guidelines for the closure and completion of mines.
- Mine rehabilitation (DITR, 2016d) – provides guidelines and practices for mine rehabilitation.
- Stewardship (DITR, 2006) – provides guidelines to encourage the application of stewardship.
- Community engagement and development (DIIS, 2016b) – addresses the key issues related to how mining companies interact with people including community engagement and community development.
- Leading practice sustainable development in mining (DRET, 2011) – updates and consolidates these earlier leading practice guides to reflect the mining life cycle.

3. SETTING

This chapter provides contextual information concerning the physical, biological and social environment of the FRCGP disturbance area and environs. This information establishes the context in which closure issues and plans can be discussed and has been sourced primarily from the following documents:

- Environmental Impact Statement for the Sepik Development Project (Coffey, 2018a).
- Frieda River Copper-Gold Project Feasibility Study Report (FRL, 2018).
- Social Impact Assessment for the Sepik Development Project (Coffey, 2018b).

Additional studies and literature were used where required to supplement these reports.

3.1 Geography

The FRCGP mine area is situated on the northern slopes (up to around 1,400 m above sea level) of the Central Cordillera of PNG, within the watershed of the Sepik River. The altitude of the region generally decreases towards the northeast of the deposit where the valley slopes reduce near the main course of the Frieda River. The Frieda River flows out of the mountainous region into relatively flat terrain, where riverbanks are regularly inundated and poorly drained, and subsequently flows northward to its confluence with the Sepik River, which is approximately 30 m above sea level.

The infrastructure corridor traverses generally northwest from the mine area through the Saniap, Usake and Upper May river catchments in the East Sepik Province. The corridor then travels north through the lowlands of the Sepik River floodplain in Sandaun Province, before travelling over the Bewani Mountains and the northern coastal plain to Vanimo on the northern coast of PNG.

3.2 Physical Environment

3.2.1 Climate

The region is classified as wet tropical with recorded average monthly temperatures varying between 21 and 23ºC. Temperatures are generally higher in the floodplains than in the highlands. Relative humidity is consistently high, with maximum monthly humidity in the order of 95 to 100% and minimum monthly humidity between 40 and 55%.

Rainfall on the higher elevations of the mine area (average annual rainfall from 6,900 to 8,200 mm) is greater than the Sepik River floodplain (average annual rainfall from 3,600 to 4,600 mm) and Vanimo (approximately 2,600 mm). Similarly, the mean daily rainfall is considerably higher in the hill zone (23 mm per day) than on the Sepik River floodplain region (11 mm per day) or the northern coast. The Sepik River floodplain region, located at lower elevations, experiences greater rainfall seasonality compared to the mine area with lower rainfall recorded between May and October.

3.2.2 Hydrology

In the higher elevations of the mine area, steep, rapidly flowing mountain streams, including the Ok Binai, Isai Creek, Simbale Creek, Ekwai Creek and Ubai Creek, are flanked by dense tropical rainforest. The major rivers that the infrastructure corridor intersects include the Usake, May, Idam, Faring, Bapi, Yenabu and Nemayer Rivers and various tributaries. Given the limited storage capacity of their catchments, these watercourses can rise rapidly during rainfall events. Mountain streams and creeks converge to form larger rivers, including the Nena, Niar, Frieda, Wario and Wogamush rivers, all of which are tributaries of the large lowland river, the Sepik River.

Features of watercourses within, or adjacent to, the mine area allow them to be categorised into three groups:

- Upland creeks: all creeks above RL 150 m, and those dominated by cascades, rapids, waterfalls or regular riffles.
- Upland rivers: all rivers above RL 150 m.
- Mid-catchment rivers: rivers below RL 150 m and generally still confined by the surrounding geology.
- Large lowland rivers with high, lateral mobility, extensive floodplains and off-river waterbodies (e.g., ox-bows), that have high turbidity with sandy substrates and deep, central channels and outer meander bends.

3.2.3 Geology and Soils

Northern New Guinea is an active tectonic area with a complex geologic history. The flat plains, which form this ecoregion, have been compressed between the foothills of the Central Cordillera to the south and the Van Rees, Torricelli and Foya mountains to the north. The surface geology consists of clastic sedimentary rocks and recent alluvium. In the highlands, volcanic rocks (mainly basalts) are most common.

The mine area lies on the Frieda River Igneous Complex, in the northern foothills of the Central Cordillera, towards the southern margin of the New Guinea Thrust Belt. The igneous complex is approximately 17 km long by 7 km wide and is considered to be the remnants of a large stratavolcano. Mineralisation comprises a cluster of copper-gold deposits, with the most significant of these being the Horse-Ivaal-Trukai, Ekwai and Koki (HITEK) porphyry deposits.

Waste rock from the mine will contain elevated concentrations of sulphides and have low acid-neutralising capacity. As such, there will be a high potential for acid and metalliferous drainage (AMD) to occur. Given the expected low acid-neutralising capacity of waste rock and assuming that the sulphides are reactive, the lag period for potentially acid-forming (PAF) rock to acidify is likely to be relatively short and in the order of weeks to months rather than years.

A wide range of soils exists over relatively small areas due to weathering, and colluvial and alluvial soil movements. Generally, soil types show the following pattern:

- Shallow soils over highly weathered rock on the crests/upper slopes.
- Deeper (but variable) colluvial rocky and gravelly soils on the lower slopes.
- Variable alluvial clays, silts, gravels and cobbles within the base of headwater incisions, e.g., Frieda River headwaters.
- Alluvial floodplains and swamps comprise inter-bedded clays, silts, gravels, cobbles and peat.

3.3 Biological Environment

3.3.1 Vegetation and Bioregions

Three major environmental zones within the FRCGP disturbance area can be defined on the basis of unambiguous geomorphic criteria, i.e., the ‘lowland zone’, ‘hill zone’ and ‘montane zone’. The lowland zone comprises depositional landforms that result from past or present overbank flooding of the Sepik River and its major tributaries. These areas are subject to inundation on a seasonal or multiannual basis. The hill zone and montane zone are part of the northern foothills of the Central Cordillera and comprise continuous ranges and isolated hills consisting of primary

erosional and colluvial landforms. The topography is generally steep, with significant stretches of cliff line.

From a total of 63 typing codes employed by the current PNG Forest Inventory Mapping System (FIMS), at least 15 of these forest types occur in the FRCGP disturbance area. In addition, one forest type, Peat Forest, is a new formation previously undocumented in PNG and is thus uncoded under the FIMS. There were also areas of anthropic disturbance, i.e., areas cleared of vegetation. Vegetation types broadly fall within the following formations:

- Montane Forest.
- Hill Forest.
- Lowland Forest.
- Peat Forest.
- Swamp Forest.
- Successions.
- Off-river waterbodies.

The lowland zone supports characteristic vegetation communities that have been described as riverine mixed successions, open low-altitude forest on plains and fans, alluvial swamp, woodland and lowland peat forest. The vegetation of the hill zone shows gradational differences. At low to medium elevations, the vegetation is medium-crowned upland forest, but at higher elevations (typically above 1,000 m), this grades into small-crowned lower montane forest and small-crowned lower montane forest with conifers.

Botanical assessment of the flora for the FRCGP has documented the presence of species-rich habitats of exceptional floristic value, including 2 genera and 23 species new to science and 16 International Union for Conservation of Nature (IUCN) listed taxa (1 critically endangered, 1 endangered, 7 vulnerable and 7 near threatened). Since the time of the field surveys, seven of the previously undescribed species have now been described scientifically.

3.3.2 Fauna

The Sepik basin is one of Malesia's most biologically diverse riverine environments and the largest catchment in PNG. The area contains a high diversity of terrestrial fauna, in particular mammals and frogs, in comparison with other remote areas of the PNG highlands. Both flora and fauna tend to have affinities with western New Guinea.

The FRCGP disturbance area is situated in a biologically poorly known region that has received comparatively little research attention. As such, a large number of fauna species were recorded during baseline studies that are thought to be undescribed by science. However, fauna assemblages are expected to have strong commonality with large regions of the northern lowlands and foothills of the Central Cordillera, spanning all three major drainage basins of northern New Guinea – the Mamberamo in the west, the Sepik itself, and the Ramu to the east.

The mine area covers largely intact forest habitats with only small areas of disturbance caused by previous mining exploration activities and by local residents (albeit at low population densities) who carry out traditional subsistence activities, including small-scale gardening, hunting, and artisanal mining. The northern areas of the infrastructure corridor have been heavily impacted by logging activities.

Referring to the environmental zones described in Section 3.3.1:

- The hill and montane zones contain high biodiversity values due to connections with the Central Cordillera, with habitat dynamics dominated by gap phase regeneration dynamics.

- The lowland zone has diverse wetlands, with floodplain dynamics being dominated by pulsed flooding events.

During EIS characterisation surveys, a number of ecologically important features were documented:

- Montane areas (e.g., located in the hill and montane zone) that are likely to contain a number of mammals of conservation significance. These areas also contain unique fauna habitats including limestone outcrops that may contain caves.
- Hilltops (located in lowland, hill and montane zones), which are used by males of many butterfly species to establish territories and are important in the conservation of rare butterfly species.
- Riparian and lentic areas of the Sepik floodplains located in the lowland zone that provide nesting and foraging habitat for a large number of migratory waterbird species and resident waterbird populations, and also contain large populations of both New Guinea freshwater crocodiles (*Crocodylus novaeguineae*) and estuarine crocodiles (*C. porosus*) that are significant to local communities.
- Clear, fast-flowing mountain streams in the hill zone that contain distinct assemblages of frogs that rely on cool, clear streams for successful reproduction.
- Limestone areas, which contain diverse frog assemblages.
- Peat forest, which is a rare and poorly understood community on the island of New Guinea. Although species-poor, the fauna communities associated with the peat forest were highly distinctive, not only in relation to other habitats within the FRCGP disturbance area, but also in relation to those elsewhere in New Guinea.
- North Coastal Ranges, which have been noted as biologically important for the concentrations of endemic fauna.

3.3.3 Aquatic Flora and Fauna

Riparian vegetation of the Sepik River system consists of different types of herbaceous and wooded freshwater swamps. Fluctuations in water level are considerable and may be as much as 7 m in the central part of the Sepik River floodplain (Chambers, 1987). The entire Sepik floodplain is up to 70 km-wide and consists mainly of backswamps and a 5- to 10-km-wide belt of active meanders. The floodplain rivers consist of fresh water throughout their lengths owing to their large discharges and the small tidal fluctuations in the Bismarck Sea.

Ecologically, the Sepik River system is believed to be relatively species-poor compared with similar systems on the southern side of the Central Cordillera (e.g., the Fly River), having a total of some 73 native fish species (Allen and Coates, 1990). During EIS characterisation surveys for the Sepik Development Project, 29 native and 7 introduced fish species, as well as more than 40 macroinvertebrate species, were recorded.

The upper and mid reaches of the Sepik River catchment are relatively sparsely populated with high habitat integrity, greater diversity of macroinvertebrates and moderate diversity of fish compared with the lower catchment. However, the lower catchment has a higher abundance and diversity of fish and is more influenced by introduced fish species than the upper and mid catchments.

Seventeen species of fish that have been reported in the Sepik River are of conservation significance, due either to their assessment as threatened or potentially threatened species or because of their restricted range (endemism). Three species previously reported in the Sepik

River are listed in the IUCN Red List of Threatened Species: the spinach pipefish (*Microphis spinachioides*), assessed as data deficient; the freshwater gudgeon (*Eleotris aquadulcis*), listed as near threatened; and the sawfish (*Pristis pristis*, formerly *Pristis microdon*), listed as critically endangered. Neither the spinach pipefish nor the sawfish were collected during the 2008 to 2010, 2011 or 2017 sampling events, however, the freshwater gudgeon was caught at a location upstream of the confluence of the Sepik and Frieda rivers during the early 2009 surveys.

In addition to the fish, two New Guinea-endemic species of freshwater turtles are known to occur in the Sepik-Ramu River system: the New Guinea giant softshell turtle (*Pelochelys signifera*), and the spotted or New Guinea snapping turtle (*Elseya schultzei*). The New Guinea giant softshell turtle is listed as vulnerable under IUCN.

In the late 1980s to early 1990s, an initiative known as the Sepik River Fish Stock Enhancement Project (SEP) was undertaken by the Food and Agriculture Organisation (FAO) and PNG Government. The objective of this initiative was to introduce new fish species to the Sepik River system to increase the protein intake of people in the region. Eight species of African, Asian and South American fish species were introduced at locations throughout the catchment and into the Yonki Reservoir (Dudgeon and Smith, 2006). Introduced species were recorded during the baseline surveys and are dominating fish biomass in lowland rivers and off-river waterbodies. Baseline surveys found that the composition of the fish community within the Sepik River catchment, particularly in the middle reaches of the Sepik River, has been significantly changed as a result of introduced non-native species. However, there appears to be no loss of native species from any part of the upper Sepik River catchment.

3.4 Socio-economic Environment

There are three language groups present in and around the mine area, namely the Paiyamo, Miyan, and Telefol.

Both geographically and culturally, the FRCGP lies in a ‘transition zone’ between the larger populations inhabiting the high peaks of the New Guinea cordillera to the south and those living in the extensive plains of the Sepik basin to the north.

Approximately 97% of land in PNG, including that in the mine area and infrastructure corridor, remains under customary tenure. The remaining 3% is almost entirely owned by the National Government and is generally referred to as ‘alienated land’. The mine area falls under customary land tenure.

The FRCGP may influence a large number of communities, both directly and indirectly. These can be grouped into the following categories:

- **Catchment 1A**: Mine area comprising communities of Amaromin, Sokamin, Wameimin 1, Wameimin 2, Ok Isai, Wabia and Paupe.
- **Catchment 1B**: New infrastructure and road corridor, Hotmin to Green River including the communities of Uramesin 2, Temsapmin, Hotmin, Idam 1, Idam 2, Wokomo 1, Bisiabru and Green River.
- **Catchment 1C**: Existing infrastructure and road corridor, Green River to Vanimo including the communities of Amini, Kwomtari, Itomi, Kilifas, Sumumini and Imbrinis.
- **Catchment 1D**: Vanimo including the communities of Wesdeco and Cis Point.
- **Catchment 2**: Sepik River corridor comprising communities from the several language groups along the upper, middle and lower section of the river.

- **Catchment 3**: Sandaun and East Sepik Provinces.

3.4.1 Mine Area

Within the mine area there are seven villages either within or in proximity (15 to 20 km) to the proposed open-pit and infrastructure footprint, or immediately downstream of the ISF. The total population of the mine area at the end of 2017 (based on the most recent data collected from FRL) was approximately 2,000 people, with annual growth adding around 60 people per year to the population. Socio-economic characterisation, undertaken as part of the Sepik Development Project's social impact assessment (SIA) (Coffey, 2018b), recorded the following features:

- **Land Use.** Villagers rely on the surrounding environment to obtain the majority of their food from the land and rivers through harvesting and sago production, gardening, fishing and hunting.
- **Economy.** The economic environment is largely informal due to remoteness and the ensuing lack of access to markets and services or to retail or employment opportunities. Alluvial gold mining is one source of reliable income for a number of communities in the higher reaches of the Frieda River. Other sources of income in the mine area include the sale of agricultural products, handicrafts, hunted goods and fishing products.
- **Education.** On average across the villages located in the mine area, approximately 47% of the population has received no education, which can largely be correlated with it being very difficult to access education services and facilities. Only a very small proportion of the population in the area could be considered employable for occupations in any roles other than unskilled labour.
- **Health.** Infrastructure in communities is, at best, degraded or, at worst, non-existent. Health service delivery is intermittent, with health patrols and extension programs conducted rarely and in few locations. During the 2015 community surveys informants indicated that fevers due to malaria and upper respiratory tract infections and diarrhoea were the most prominent morbidity factors.
- **Governance and Law and Order.** Practices and capabilities vary with very little formal law-and-order capability. Generally, village magistrates, village councillors, community leaders and, in some cases, church leaders provide authority and administer law and order.
- **Cultural Heritage.** Villagers have considerable knowledge of places with social and cultural significance, even though they no longer believe in or adhere to the associated practices. Sepik Development Project EIS studies included a detailed assessment of archaeology and cultural heritage with over 250 archaeological and cultural heritage sites recorded. Sites of contemporary cultural significance or places of various ritual purposes included treatment of the dead and secondary burial at former settlements and caves, respectively, and ceremonies to ancestral spirits and *masali* at places of residence or association, such as spirit houses, waterbodies and sago stands. Other sites included places and paths belonging to spirits, both ancestral and *masali*, places associated with spirits through historical narrative and places where people lived or undertook important social or economic activities.
- **Transport.** Reflecting the lack of road infrastructure, the Frieda and Sepik Rivers provide the most accessible and effective transport corridor for residents living along their banks, with those communities having some access to paddle and motor canoes.

3.4.2 Infrastructure Corridor

Social profiles for Catchment 1B and 1C have been characterised together to avoid repetition of information that is applicable to the infrastructure corridor. In particular, survey results for both

social catchments have been amalgamated where possible due to their similar social profiles and survey results.

Both catchments comprises 14 villages. The new and existing infrastructure and road corridor encompasses approximately 325 km of the proposed main access route to the mine area. It runs from the village of Hotmin in a generally north direction through Green River to Vanimo. The total population for social catchment 1B totalled 2,140 during the 2017 social survey, comprising seven communities (Coffey, 2018b). Available data for the villages situated in social catchment 1C indicates a total population of 2,766, encompassing the communities of Amini, Itomi, Sumumini and Imbrinis (NSO, 2014). The total population for the communities of Kilifas and Kwomtari is unknown.

Socio-economic characterisation, undertaken as part of the SIA (Coffey, 2018b), recorded the following features:

- **Land Use.** Villagers are almost wholly engaged in subsistence activities, obtaining the majority of their food from the land and surrounding environment through gardening, fishing and hunting. Food staples including sago, taro, banana and coconut are vital to ensure food security for all villages and are generally collected from natural stands. Extensive forestry and oil palm plantation operations are prevalent along the existing Vanimo to Green River Road.
- **River Use.** Villagers use rivers as a source of drinking water and water for washing, cleaning and cooking; for fishing grounds and collection of a variety of aquatic plants; for transport and access to gardens; for rubbish disposal; and to process sago. Water infrastructure is mostly absent with water mostly sourced from rivers, lakes, natural springs and bores. Most people surveyed considered the water to be satisfactory with the exception of Bisiabru and Idam 1.
- **Economy.** Social catchment 1B is characterised by remoteness, lessening the opportunity to participate in the cash economy. Four of the communities surveyed within this catchment contain markets (Hotmin, Uramesin 2, Temsapmin and Green River), but restricted access and high transport costs limit the extent that many families can participate in the cash economy. Social Catchment 1C contained trade stores and had a greater access to roadside markets. Most households reported generating an income from the sale of garden, forest products and betel nut, as well as work in the forestry and oil palm plantation industry. The only village to report a substantial income from alluvial gold mining was Hotmin (social catchment 1B) based on the 2017 social survey. Across the catchment, formal employment is minimal, with only seven of the 35 households surveyed reporting to have received income from such sources in the past year.
- **Education.** Education levels within the catchments are low, where most people received an education up to elementary level, largely attributable to limited access to education services and facilities in the area.
- **Governance and Law and Order.** This relies on village councillors, village magistrates, auxiliary police, church leaders and village elders to administer law and order. Public infrastructure is minimal within the catchment. Villages often manage disagreements by themselves, turning to local leaders and ward development committees for assistance. Access to customary land rights is under pressure from commercial logging operations within Social Catchment 1C (AusAid, 2004). Logging operations have increased in the past 5 to 10 years (Lechner et al., 2018).
- **Transport.** There is a lack of road infrastructure in Social Catchment 1B and the only access villagers have to basic services is via long canoe rides or walking, often in excess of several

days. Although Social Catchment 1C contains road infrastructure from Green River to Vanimo, this infrastructure is poorly maintained leading to long trips to access basic services.

3.4.3 Vanimo

Social Catchment 1D comprises the capital of Sandaun Province, Vanimo and the settlements of Wesdeco and Cis Point along the north coast of PNG. The catchment consists of three representative communities within the Vanimo Urban Local Level Government (LLG) – Vanimo Town, Cis Point and Wesdeco. The total population of Vanimo Town was recorded at 13,970 according to the 2011 national census (NSO, 2014). The total population for the settlements of Cis Point and Wesdeco recorded by the 2000 national census was 651 (NSO, 2000).

Socio-economic characterisation, undertaken as part of the SIA (Coffey, 2018), recorded the following features:

- **Economy.** The coastal settlements near Vanimo Town subsisted on fishing and low intensity mixed staple gardens such as sago and coconut crops. Due to their location, fishing is the key subsistence activity practiced. Opportunities to earn an income include selling fresh food such as surplus garden produce, fish, seafood and betel nut at market places in Vanimo town centre, Wesdeco and Cis Point. Income is also derived from wages and royalties from forestry operations near Vanimo and Aitape, and participation in small-scale tourism operations.
- **Education.** The highest grade level of education achieved by the settlements of Wesdeco and Cis Point was elementary level. There are a range of educational services available within the Vanimo Urban LLG including elementary, primary, secondary and private schools.
- **Health.** The main illness that appears to be hyperendemic to all communities within the catchment is malaria. There are medical facilities and health services within the Vanimo Urban LLG including the Vanimo General Hospital. Most services lacked facilities and labour to ensure the population receives adequate treatment.
- **Governance and Law and Order.** This is generally administered by local government magistrates, land mediators and community leaders. Vanimo supports infrastructure and institutions to maintain law and order such as a police station and a court house but are under-funded and under-resourced to manage issues.
- **Transport.** Road infrastructure in Vanimo town links settlements within the catchment. Most road infrastructure in the social catchment is in poor condition and road connections to other main towns (such as, Vanimo to Aitape) are limited. Other infrastructure includes an airport and an ocean port.

3.4.4 Sandaun and East Sepik Provinces

According to NSO (2014), the total population in 2011 for the Sandaun Province was 248,411 and the total population for the East Sepik Province was 450,530. Sandaun Province is one of the most remote provinces of PNG, and East Sepik Province covers a vast area with many isolated areas due to challenging terrain and flooding along lower reaches of river plains. Socio-economic characterisation, undertaken as part of the SIA (Coffey, 2018), recorded the following features:

- **Economy.** Most residents are not employed in the formal sector with rural people in the Sandaun Province among the poorest in PNG. People use the land to grow crops such as taro, yam, sago, and banana. As with Sandaun, the Sepik River acts as a lifeline for a large part of East Sepik providing water, fish and a mode of transport (Hanson et al., 2001).
- **Education.** Within the Sandaun Province in the district of Telefomin and Nuku there were 27 community schools and 32 elementary schools run by the government. The literacy rate in

Sandaun Province in 2000 was 44.2% (compared with the PNG average rate of 64.1%); 10.4% had completed Grade 10 (compared with the national average of 17.4%). Access to education is limited within East Sepik Province. Many students from rural areas are required to travel large distances or live away from home in order to attend school.

- **Health.** Sandaun Province is one of the most under-resourced provinces in PNG with regards to health infrastructure, with only 2.4 doctors, 59 nurses and 323 hospital beds per 100,000 people (Dugue and Izard, 2004). Like Sandaun province, access to health facilities in East Sepik is limited and there is only one hospital in the East Sepik area, located at Wewak.
- **Governance and Law and Order.** Services and capabilities vary, however, overall there is very little formal law and order capability. Generally, village magistrates, village councillors, community leaders and, in some cases, church leaders provide authority and administer law and order, although there is a provincial court in Wewak.
- **Transport.** Only the coastal areas and inland hills of Sandaun Province have a relatively good network of roads. Poor roads are a major constraint to development in other areas of the province. There are often limited funds for maintenance and some roads become impassable after extended periods of wet weather. Road infrastructure is limited. The Sepik Highway runs from Wewak to Maprik and is the largest road in the region. The sealed roads in urban areas are largely poorly maintained and few sealed roads exist outside urban areas and the Sepik Highway. Travel by boat along the Sepik River system is a popular means of travel. The river plays a vital part in transporting agricultural goods and fish to market.

3.4.5 Preferred Points of Hire and Workforce

FRL will endeavour to recruit the majority of its workforce from within PNG and with a preference to employ people from the Sandaun and East Sepik provinces, particularly those in landowner communities and those affected by the Sepik Development Project. There will be an opportunity to recruit and train local people from in and around the mine site and associated infrastructure. However, it will also be necessary to source qualified and skilled employees from outside local communities for trades, technical and professional roles. Recruitment for highly specialised and experienced managerial roles may require sourcing from outside of PNG.

FRL has designated five recruitment zones, which consist of:

- **Zone 1**. PNG national. Landowning communities in the Special Mining Lease (SML), Mining Lease (ML) and the Lease for Mine Purpose (LMP) including Wabia, Ok Isai, Paupe, Wameimin 2, Wameimin 1, Sokamin and Amaromin.
- **Zone 2**. PNG national. Any community within the Telefomin LLG and the western part of the Tunap Hunstein LLG, along the infrastructure corridor, and along the Sepik River downstream of the Frieda River.
- **Zone 3**. PNG national. Sandaun or East Sepik provinces.
- **Zone 4**. PNG national. Anywhere within the Greater PNG.
- **Zone 5**. Expatriate.

Workforce numbers for the Sepik Development Project will peak at approximately 3,500 personnel (direct and indirect) during construction, including approximately 900 contractors for the FRHEP. The operational workforce will be approximately 1,600 employees.

FRL will endeavour to target 95% PNG national labour during the Project life with higher expatriate involvement expected during construction, ramp-up and early operations. Recruitment will be subject to qualifications, skills, experience and budget.

The proportion of direct employee targets from respective points of hire are shown in Table 3.1.

Table 3.1 Direct employee targets from respective points of hire

	Point of Hire	Proportion (%)
Sandaun/East Sepik provinces	Zone 1	6
	Zone 2	25
	Zone 3	42
Other PNG	Zone 4	22
Outside of PNG	Zone 5	5

4. PROJECT DESCRIPTION

4.1 Overview

The FRCGP comprises a large-scale open-pit mine operation feeding ore to a comminution and flotation process plant producing a copper-gold concentrate for export to custom smelters. The process plant will be located approximately 10 km northeast of the open-pit, with the copper-gold concentrate transported via a buried concentrate pipeline to a concentrate handling and export facility located at Vanimo (Figure 1.1).

The ISF will provide storage for both tailings and waste rock. Over the life of the mine approximately 1,450 Mt of waste rock will be extracted and approximately 1,500 Mt of tailings will be produced. To limit the potential for this material to generate acid and metalliferous drainage, best practice waste management will include subaqueous deposition of the mine waste rock and tailings in the ISF.

Concentrate slurry will be transported via a concentrate pipeline to a dewatering, storage and export facility located at Vanimo. At the concentrate export facility, the slurry will be thickened and filtered to produce the concentrate for export. The concentrate storage shed will be used as a buffer storage. A reclaim conveyor will deliver the filter cake from the concentrate storage shed to the ship loader ready for export.

4.2 Organisational Responsibility and Partners

The FRCGP will be developed by FRL (a PNG incorporated company owned by copper and gold producer PanAust Limited (PanAust) on behalf of the joint venture between FRL (80%) and Highlands Frieda Limited (20%).

PanAust is wholly owned by Guangdong Rising Assets Management Co. Ltd (GRAM), which is a Chinese state-owned company regulated under the State-owned Assets Supervision and Administration Commission, the People's Government of the Guangdong Province in China. PanAust has a portfolio of projects in Laos, PNG, Myanmar and Chile. PanAust operates to international standards with two producing assets in Laos: the Phu Kham Copper-Gold Operation and the Ban Houayxai Gold-Silver Operation. The Company's corporate office is located in Brisbane, Australia.

Highlands Frieda Limited is a wholly owned subsidiary of Highlands Pacific Limited, which is a PNG incorporated company, listed on the Australian Stock Exchange (ASX) and Port Moresby Stock Exchange (POMSoX). Approximately 30% of Highlands Pacific share register is held by the PNG Government and PNG based funds with the rest by international investors. Highlands Pacific holds Exploration Leases in the Star Mountains and on Normanby Island. It also has an investment in the Ramu Nickel-Cobalt Mine near Madang.

4.3 FRCGP Components

Activities associated with the FRCGP will occur in four distinct operational zones:

- Mine area – includes the HITEK open-pit (comprised of the HIT, Ekwai and Koki open-pit), process plant, site accommodation village, conveyor, mine infrastructure area (MIA), mine access road between Hotmin and the mine, link road between the mine and the hydroelectric power facility, transmission line from the hydroelectric power facility to the mine and other ancillary infrastructure (as shown in Figure 1.2).

- ISF and supporting infrastructure. Note: This plan does not cover closure of FRHEP facilities; however, this area is discussed in this plan in relation to FRCGP activities, in particular placement of mine waste rock and tailings within the ISF.
- Infrastructure corridor – includes the public access road from Vanimo to the mine site (the last portion of which will be a private road) alongside which the concentrate pipeline will be buried, Green River Airport, and other ancillary infrastructure as shown in Figure 1.1. Note: the scope of this plan does not include public infrastructure.
- Vanimo Ocean Port – includes the export facilities at Vanimo where concentrate will be discharged from the pipeline, dewatered, stored and loaded to ocean-going vessels for shipment to overseas markets (see Figure 1.1). An industrial area will be located in Vanimo for support facilities.

4.3.1 Mine and Associated Infrastructure

The mine and associated infrastructure will include:

- Open-pit – ore and waste rock will be mined using conventional drill and blast, load and haul methods.
- Run of mine (ROM) pad and primary crushing facility – ore from the mine will be delivered by mining trucks to the ROM pad, which will gravity feed the primary crusher adjacent to the open-pit.
- Ore conveyor system and crushed ore stockpile – a 9 km overland conveyor system will transfer ore from the primary crushing facility to the process plant, and waste rock from the waste rock crushing facility to the barge loading facility where the waste rock will be subaqueously deposited in the ISF.
- MIA – will be located close to the open-pit and will include administration buildings, vehicle maintenance workshops, hydrocarbon storage area and refuelling, fuel storage, washdown facilities, warehouse and laydown area, tyre workshop, muster and training areas.
- Process plant – ore will be processed in a process plant using comminution and flotation technology that will produce a copper-gold concentrate. This facility includes a primary crushing, conveying, ore storage and reclaim, primary grinding and pebble crushing, re-grinding and flotation circuits; concentrate thickening and pumping, tailings thickening; and reagent storage facility, consumables and distribution system.
- Ok Binai waste dump – will be established in the Ok Binai Valley to receive organic waste and topsoil from the pre-strip of the HITEK open-pit. Non–acid-forming (NAF) waste rock extracted during Year-1 prior to construction of the conveyor will also be placed in this dump.
- Limestone quarry waste dump – will be established in the Ok Binai Valley to receive spoil from construction of nearby infrastructure.
- Explosives magazine – will be located near a tributary of Nena River (Uba Creek) approximately 2 km upstream of the Nena River's confluence with Ubai Creek. The facilities will include bulk explosive storage and preparation pad (100 m x 50 m), explosives storage magazine, access roads between each area and a high security 3-m-high perimeter fence.
- Raw water pipeline – raw water will be sourced from the ISF at a rate of approximately 3,800 cubic metres per hour (m^3/h) for ore processing and general non-potable consumption including fire water for site accommodation village and other facilities at the mine. Potable water will be sourced from the Nena River upstream of the Ubai Creek and pumped to the site accommodation village. Raw water will be stored in a 3.2 ML tank. A potable water treatment

plant, located at the highest point in the site accommodation village, will be fed raw water from the storage tank and enable gravity flow to the site accommodation village and administration area via a dedicated reticulation system. The facilities will include a weir across the Nena River and a raw water intake and filter.

4.3.2 Integrated Storage Facility

Geochemical characterisation testwork indicates that the majority of waste rock and tailings from the HITEK deposits are likely to be PAF. Therefore, the emplacement strategy for the tailings and waste rock has been designed to limit the potential for acid production through the use of a flooded-cover ISF. The ISF embankment will be constructed in the Frieda River catchment approximately 16 km downstream of the mine and 35 to 40 km upstream of its confluence with the Sepik River. The reservoir will have an ultimate footprint of approximately 12,400 ha.

Tailings will be delivered to the ISF from the process plant via a floating 10 km pipeline system consisting of a carbon steel section and a high-density polyethylene pipe. Tailings will be deposited via a tremie pipe supported by a relocatable deposition pontoon which will allow tailings to be deposited below the ISF epilimnion.

During the early filling stages (i.e., first 10 months) of the ISF, prior to the surface of the lake reaching the minimum operating level of the barge loading facility (RL 199 m), PAF waste will be transported by truck and deposited on dry land at the headwaters of the lake at confluence of the Nena and Ok Binai rivers.

Once the surface NAF dump is at capacity, all NAF and PAF waste will be deposited using barges after it is crushed using two gyratory crushers to reduce the size and facilitate conveyor transport from the mine to the barge-loading facility. The barge loading facility will be a single fixed location for the life of the mine (Figure 1.2). Ultimately, the ISF will store approximately 1,450 Mt of waste rock and approximately 1, 500 Mt of tailings and will consist of a large waterbody covering an area of about 12,400 ha, which will remain as a permanent landscape feature.

4.3.3 Power Supply

Power during construction will be provided by diesel generators located at major infrastructure locations including the open-pit, MIA and process plant.

Operational power for the FRCGP will be supplied primarily by the FRHEP hydroelectric power facility. The mine's power demand will be approximately 180 MW increasing up to 280 MW by Year 8. Power will be provided to the mine via a 22-km-long 132-kV transmission line between the hydroelectric power facility to the process plant. Additional power will be required for FRCGP off-site facilities including the concentrate handling and export facilities and infrastructure area at Vanimo (4 MW) and two concentrate pipeline pump stations (7 MW in total). This power will be provided by the hydroelectric power facility via the Northern Transmission Line.

The main components of the power generation system will include:

- Substation switchyards – A powerhouse substation located at the process plant, consisting of eight 80 MVA transformers, two 22 MVA transformers and gas insulated 132 kV switchgear. Substations are part of the SPGP and therefore outside the scope of this closure plan.
- The 22-km-long 132 kV transmission line containing twin overhead earth wires, from the powerhouse to the process plant will be held up by self-supporting galvanised lattice steel towers and galvanised steel monopoles. Power at other project locations including the site accommodation village, administration and training, explosives storage, mine infrastructure area and waste management facilities will be supplied by various medium voltage (MV)

substations. The MV substation will be located at the process plant and power will be supplied by overhead distribution lines.

4.3.4 Export and Import Facilities

The concentrate export facilities for the FRCGP comprise the concentrate export route along the infrastructure corridor alignment and the concentrate export facility at Vanimo Ocean Port. This will include:

An infrastructure corridor will be developed and operated for the purpose of transport and access.

- Concentrate pipeline – connecting the process plant to the concentrate handling and export facility, the buried 325-km-long concentrate pipeline route will generally follow the main access road to minimise vegetation clearance and provide access to the pipeline if required. The main components of the concentrate pipeline system include the concentrate pipeline and two booster pump stations (2 MW each), one located near Green River and one approximately 5 km to the southwest of Itomi. The pipeline will be constructed of welded high-tensile carbon steel pipe with a diameter of approximately 200 mm. The pipeline will be buried for its entire length with the exception of river crossings where it will be suspended below bridges.
- Roads – the regional public road (from Vanimo to Hotmin) and private mine access road (Hotmin to site) will enable passenger and freight access during construction and operation of the mine. The main haul road will transport ore and waste from the open-pit to the ROM pad, the Ok Binai waste dump and waste rock crushing facility. The link road will run from the site accommodation village to the powerhouse and the HITEK access road will run parallel with the overland conveyor from the site accommodation village to the HITEK open-pit. Road construction materials will be sourced from new quarries to be developed adjacent to the road corridor and from the diorite quarry.
- Concentrate export facility – located at the Vanimo Ocean Port and will comprise dedicated facilities for concentrate dewatering and handling upon the port apron, including: concentrate thickener and filter plant, concentrate storage shed, ship loading facility, water treatment plant, bulk diesel pipeline and diesel generators.
- Vanimo infrastructure area – consisting of a multi-purpose industrial area located adjacent to the main access road. The Vanimo infrastructure area will include FRLs regional office, permanent accommodation, warehouse and laydown yard, freight storage, maintenance workshop, and bulk diesel storage tanks. This area will be the key facility for imports.

4.3.5 Ancillary Infrastructure

The FRCGP will include development of ancillary infrastructure, such as:

- Accommodation – on-site accommodation will be located in the Nena River valley approximately 5 km from the process plant and will accommodate up to 3,500 personnel during construction. During operations, the site accommodation village will house approximately 2,780 and a further 100 personnel will be accommodated at Vanimo for office, logistics and port operations.
- Green River facilities – hosting several features to support the FRCGP due to its proximity to the Green River Airport. A bus terminal facility will be located adjacent to the airport terminal and a concentrate pump station, including diesel generator, will be located south of Green River.
- Quarries – these will be excavated to provide materials for the construction of dams, roads, water diversion bunds, infrastructure pads and the construction of the ISF embankment.

Quarries will be located within or directly adjacent to proposed infrastructure footprints, where practicable. A diorite quarry located east of the HITEK open-pit will provide competent rock for the haul road construction, maintenance and blast hole stemming. A limestone quarry will be used to source material for use in the process plant and will provide limestone for the water treatment plant.

- Communications – a fibre optic cable will run along the concentrate pipeline enabling communications between the process plant, booster pump stations and the concentrate filter plant located at the Port of Vanimo.
- Emergency power facilities – An emergency power station located at the site accommodation village will provide power to mine site facilities including the process plant and site accommodation village during temporary transmission line or hydroelectric power facility outages.

5. STAKEHOLDER IDENTIFICATION AND CONSULTATION

Stakeholder consultation regarding closure is required to ensure that interests and concerns of stakeholders, as well as sustainable outcomes, are considered during the closure planning process. Guiding principles of this process are honesty and transparency, providing clear, timely information and giving opportunities for stakeholder input in the closure planning process. Stakeholder identification and consultation avenues for the FRCGP are discussed briefly in the following section.

5.1 Stakeholder Identification

Stakeholder identification is a key step to establishing relationships and to enable tailored stakeholder engagement activities to be developed. Stakeholders were identified through both 'top down' and 'bottom up' processes drawing upon baseline studies and verified through engagement with stakeholders and host communities to ensure that all key stakeholders have been identified.

Stakeholders were initially characterised and prioritised during a stakeholder engagement workshop in Brisbane in December 2008. The analysis involved identification of the FRCGP's primary stakeholders and consideration of their likely interests and concerns. The stakeholder analysis was reviewed in 2015 and then progressively updated on completion of the various studies and surveys during 2015, 2016 and 2017.

The review of stakeholders was based on the IFC's Performance Standard 1: Social and Environmental Assessment and Management Systems (IFC, 2012). This process was based on the following steps:

1. *Identify individuals, groups or local communities that may be affected by the project, positively or negatively, and directly or indirectly, making special effort to identify those who are directly affected, including those who are disadvantaged or vulnerable.*

   Stakeholders were initially identified through consideration of the geographic footprint of the FRCGP. The list was then expanded and updated as findings from specialist studies became available.

2. *Identify broader stakeholders who may be able to influence the outcome of the project because of their knowledge about the affected communities or political influence over them.*

   This involved consideration of the geographic footprint of the project and assessment of government organisations, institutions and non-government organisations that may have an interest in and/or influence over the project.

3. *Identify legitimate stakeholder representatives, including elected officials, non-elected community leaders, leaders of informal or traditional community institutions, and elders within the affected community.*

   Stakeholder representatives were identified through engagement with the communities identified in step 1. Representatives of minority groups have emerged or been sought out during engagement with communities.

4. *Map the impact zones by placing the affected groups and communities within a geographic area to define or refine the project's area of influence.*

Stakeholders have been mapped and arranged into groups based on their level of interaction with the project and stakeholder engagement methods.

Steps 1 to 3 have been revisited with material changes to the design to ensure that all affected stakeholders are recognised as the design progressed.

Stakeholders are summarised according to the following categories:

- Host communities:
  - Landowners and impacted land users of the Special Mining Lease area and Lease for Mining Purposes.
  - Communities along infrastructure corridor and those communities resident along or reliant upon the Sepik River.
  - Communities in the Sandaun and East Sepik Provinces.
- Government and regulatory stakeholders:
  - PNG national government.
  - CEPA.
  - MRA.
  - Mining Advisory Council.
  - Other PNG government departments.
  - Sandaun and East Sepik provincial governments and potentially-impacted local-level governments (LLGs) within these two provinces.
- Internal stakeholders including FRL and PanAust managers, employees, contractors and their families and business functions.
- Other stakeholders:
  - Owners and investors (owners of the joint venture, Board of Directors and investors).
  - Local suppliers (consisting of key local, regional and national suppliers to the FRCGP).
  - Other suppliers (consisting of key international suppliers).
  - Financiers and insurers.
  - Industry (including other resource sector projects in close proximity to the FRCGP, as well as research and industry associations).
  - Community-based groups (including charitable organisations, environment groups and NGOs).
  - Local services and utilities (hospitals, healthcare, educational facilities, utility providers and emergency services)

This list will continue to evolve throughout the life of the FRCGP.

5.2 Stakeholder Consultation for Closure

A stakeholder engagement plan has been developed to guide stakeholder engagement. The plan identifies who needs to be engaged, why and on what issues, and describes the processes, systems and required resources that will enable FRL to effectively undertake leading practice stakeholder engagement. This plan will be reviewed periodically.

The closure consultation process aims to keep stakeholders informed by developing and agreeing on final closure objectives and criteria, and on a process for the handover and relinquishment of the leases following closure. Specific objectives are to ensure that:

- Stakeholders are included in the closure process, have their interests considered, and have the resources to participate meaningfully in the process.
- All outcomes agreed to are achievable and sustainable, and ensure that the long-term integrity of the site is maintained.
- Requirements of the government and community are met.
- Maximise the potential social opportunities following mine closure (as discussed in the following section).

The closure consultation process will be part of FRL's broader stakeholder consultation, involving both formal and informal processes, and will build on that established during pre-feasibility and feasibility stages of the FRCGP, e.g., briefings, roadshows, fact sheets and use of local community noticeboards. These mechanisms will be further expanded and refined during operation to ensure their ongoing relevance and effectiveness. Specifically, FRL will:

- Establish a closure steering committee, integrated into an overall stakeholder engagement strategy that can provide a useful forum for discussion and communication on closure issues. This is likely to involve combining members from the government reference group and landowner leaders group, which will exist during construction and operations, and will occur towards the end of operations.
- Identify and engage key stakeholders in a consultation program, where their concerns and interests can be considered during mine closure planning. Key stakeholders are likely to include:
  - FRL: employees, contractors and management.
  - Community: local communities and nearby landowners.
  - Sandaun and East Sepik provincial and local level governments.
  - National government, particularly CEPA, MRA and Treasury.
- Undertake workshops and focus groups to develop specific closure strategies.
- Undertake consultation to identify and address concerns of specific groups.

6. OPPORTUNITIES

Opportunities created by FRCGP closure can be divided into two main areas: social and closure research. These are discussed in the following sections.

6.1 Social

The over-arching objective in relation to mine closure is to minimise adverse impacts and optimise benefits on the surrounding community. As such, a number of potential social initiatives could form the basis for initial discussions, notwithstanding the need for community empowerment and their involvement in shaping closure opportunities and responsibilities. These potential opportunities for social development during closure include:

- **Capacity building.** Approaches to build capacity and transfer skills within both mining communities and local governments to maintain essential services beyond the life of the mine could be investigated during the closure consultation process. Potential areas of focus during the operations and could include: local employment, education and training, mine and non-mine dependent business development, and infrastructure for development.
- **Health**. Approaches to improve local and regional health and wellbeing is viewed as a priority to be pursued during operations to have lasting benefits beyond the life of the mine and will be investigated during the closure consultation process.
- **Agriculture and forestry.** Disturbed (and successfully remediated where required) areas could be converted into cultivatable farmland, gardens or sustainable agriculture or forestry.
- **Food security.** Food security planning, agricultural training and other support may be undertaken to ensure that communities can re-establish the ability to grow food crops after the direct boost to the local cash economy provided by the mine is exhausted. All of these opportunities will be subject to ongoing discussion with stakeholders during closure planning, which will occur throughout the life of the FRGCP.

Stakeholder engagement regarding these potential opportunities and any others will be a key aspect for stakeholder consultation as the mine nears closure. As outlined in the PanAust Closure Standard, operations will consider impacts of closure on the surrounding communities, including locally employed staff, contractors and suppliers. A socio-economic impact assessment (SIA) will be conducted at least five years prior to closure that will assess potential post closure opportunities in detail.

6.2 Closure Research and Trials

Considering the conceptual nature of the current stage of closure planning for the FRCGP and the currently-proposed 33-year mine life, there are a range of research topics and trials that are planned. These will aid in future closure planning and refinement of the current closure options.

Areas for future investigation and potential further opportunity include (but are not limited to):

- **Water treatment.** A water treatment plant will ensure discharged water quality is better than the PNG water quality criteria for aquatic life protection. Once mining operations have ceased, decommissioning will commence and is expected to take three years. Active water treatment will be required during this time and infrastructure will be needed to support this. Treatment of poor water quality may include a range of treatment options such as in-pit microbial sludge treatment and other extraction systems such as electrolysis.

- **Rehabilitation substrates**. Since topsoils are unlikely to be stockpiled for rehabilitation (see Section 9.3.1), research and trials will be conducted investigating 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.
- **Revegetation**. Revegetation trials 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 also investigate the success of different revegetation methods such as hydroseeding, direct planting and natural regeneration.
- **Social performance indicators**. FRL will conduct regular review of social performance indicators to assess sustainable improvements to economic and social well-being and adapt community investment accordingly based on these reviews.

6.2 Corporate

It is envisaged that the FRHEP will enable a reliable, long-term supply of energy long after the FRCGP has closed. As such, there is the possibility for the transfer of responsibility for containment of waste rock and tailings and also post closure open-pit water treatment associated with FRCGP after relinquishment of the mining tenements. Noting the conceptual nature of closure planning, it is envisaged that any handover of liabilities associated with FRCGP to FRHEP would need to be associated with a financial closure provision. Such a provision could take the form of a trust fund developed over the course of FRCGP operations to ensure financial surety to conduct the necessary monitoring and maintenance.

Prior to the relinquishment of mining tenements, opportunities to transfer liabilities associated with the FRCGP, including post closure open-pit water treatment and downstream water quality, will be investigated.

7. RISK ASSESSMENT

Good practice requires closure objectives and impacts to be considered from inception. The closure of the FRCGP will result in a number of environmental and social risks, each of which requires consideration in accordance with regulations and guidelines, and consultation with stakeholders, to produce a detailed mine closure plan.

7.1 Conceptual Closure Workshop

A conceptual closure risk assessment workshop was conducted in November 2015 for an earlier design of the FRCGP to determine key risks and opportunities with regards to closure and to generate the Closure Risk Register. Participants were key stakeholders from FRL and consultants with a broad range of skills and experience to assist in outlining the risks associated with closure.

The risk assessment process allows for risks to be prioritised such that, through the closure planning process, control measures can be designed and implemented to eliminate or reduce the risk ratings to acceptable levels (which will be determined in consultation with stakeholders). The objectives of the risk assessment workshop were therefore to:

- Review risks specific to the rehabilitation and closure of the FRCGP.
- Determine and discuss the proposed measures to ameliorate these closure risks and whether the proposed rehabilitation and closure strategies are adequate.
- Identify information gaps and uncertainties regarding closure strategies.
- Consolidate relevant information into this plan.

For the closure risk assessment workshop, the site was divided into smaller discrete areas, or domains (see Chapter 10), to assess risks associated with those particular areas in which most of these areas are applicable to this plan. These included:

- Mine and associated infrastructure, including open-pit, concentrator, mine facilities area, and explosives magazine.
- Integrated storage facility and waste handling.
- Access and transport corridor, including access roads and concentrate pipeline.
- Ancillary infrastructure.

Employment and community risks, and internal company risks were also assessed.

7.2 Risk Assessment Framework

The risk assessment was conducted by examining the potential consequences (i.e., the severity of social, environmental and financial impacts) and the likelihood that those impacts will occur. The assessment of ‘likelihood’ rating applies specifically to the resulting environmental or social impact.

The risk assessment method was adapted from, and in accordance with, the following:

- PanAust Group’s Risk Management Framework and assessment tool.
- The Australian standard for risk management and its principles and guidelines (Standards Australia, 2009).

- The Australian standard for environmental risk management and its principles and process (Standards Australia, 2006).

The main elements for risk management include:

- Establish the context. Determine the external, internal and risk management context in which the rest of the process will take place.
- Identify risks. Where, when, why and how events could prevent, degrade, delay or enhance the achievement of the objectives.
- Analyse risks. Identify and evaluate existing controls. Determine consequences and likelihood and, therefore, the level of risk.
- Evaluate risks. Compare assessed levels of risk against the pre-established criteria and consider the balance between potential benefits and adverse outcomes.
- Mitigate risks. Develop and implement specific cost-effective strategies and action plans for increasing potential benefits.
- Monitor and review. Establish the effectiveness of all steps of the risk management process.

Each aspect (i.e., domain area) was assessed for its potential environmental, economic, social and regulatory risk factors. A product of this process was the creation of a comprehensive Closure Risk Register that identifies the issues, their risks and their priority.

7.3 Conceptual Closure Issues

Preliminary high-level environmental and social risks for mine closure were identified and assessed during the workshop. These issues were considered when developing the closure strategy (see Chapter 10).

The assessment assessed 40 main potential risks, producing: 5 high risk scores, 30 medium risk scores, 1 low risk score and 4 positive impact scores.

The risk that was rated as being of a high level (following the application of mitigation measures) was:

- Spillway becomes blocked by debris or landslide and maintenance cannot clear the blockage, causing the dam to overtop, eroding the main embankment and potentially resulting in dam embankment failure and release of mine waste rock and tailings, and subsequent downstream impacts. This risk also relates to the operation of the hydroelectric power facility.

Other risks that rated as medium risk levels included (but were not limited to):

- Poor rehabilitation of disturbed areas leading to erosion and loss of topsoil and lower overall recovery of terrestrial biodiversity.
- Contaminated soils due to the failure to remove or rehabilitate areas of contamination, which could subsequently affect future land uses.
- Risks associated with the ISF and open-pit, including failure of diversion and decant tunnel plugs.
- Inadequate prediction of open-pit and ISF water quality (e.g., as a result of AMD) causing unexpected downstream impacts.
- Failure to maintain infrastructure appropriately, such as the water treatment plant and clean water diversions.

Previous experiences in PNG have shown that mines often become the local economy's primary provider of income, employment and services. In such a context, mine closure has the potential to have adverse impacts on the well-being of the community, with specific social issues being:

- Economic reliance on the FRCGP with the consequent loss of direct economic benefits, royalties and taxes causing social problems once the mine has stopped operations.
- Increased access to corridor villages and resettlement areas during closure resulting in in-migration to villages along the road corridor, thereby causing conflict, competition for resources and social tensions.
- Ill-informed (or misinterpreted) mine closure concept and timing leading to community unrest.
- Failure to define closure criteria and end land uses to meet community expectations.
- Safety of people due to the failure to maintain safe, stable landforms in the long term.
- Decline of community social structure and infrastructure post closure resulting in non-functioning education, health, and policing services.

Measures to address these environmental and social issues are described in Chapter 10.

8. CLOSURE FRAMEWORK

8.1 Approach

Early consideration of mine closure in project planning is essential to avoid or minimise adverse, long-term environmental and social impacts and reduce the cost of rehabilitation and environmental management at closure. Key principles essential for successful mine closure include development of:

- A closure framework (including closure objectives, and criteria and indicators).
- Suitable rehabilitation maintenance and decommissioning techniques and plans.
- A strategy for unforeseen circumstances such as unplanned mine closure.

FRL's closure framework establishes its overall objectives, and criteria and indicators of success for the closure of the FRCGP. Completion criteria and indicators are site-specific and cover a range of aspects. These are used to group objectives and provide a basis for each major risk, as identified in the mine closure risk assessment (see Chapter 7), to be adequately addressed in this plan.

At this stage of the project, completion criteria are conceptual in nature and require further development as planning progresses. The closure framework consists of:

- **Objectives.** A clear set of statements relating to environmental and social aspects of mine closure that describe the intent of the mine closure program.
- **Criteria.** These describe specific elements that can be measured or certified to have occurred, and that are considered to be critical to achieving the objectives. Each objective may have more than one criterion, and a criterion may apply to more than one objective.
- **Indicators.** These may be either an agreed value that is measurable and is regarded as the minimum that must be achieved, or a certification that specific closure activities comply with an agreed plan for those activities.

These definitions are consistent with the guidelines and procedures detailed by PanAust (2014), ICMM (2008b) and ANZMEC and MEC (2000).

8.2 Closure Objectives

FRL has developed a set of closure objectives to achieve acceptable outcomes for closure and rehabilitation of the FRCGP. These objectives provide the basis for conceptual completion criteria presented in Section 8.3 and are as follows:

- Provide an agreed process for the planning, validation and reporting of decommissioning and rehabilitation activities.
- Consult with internal and external stakeholders to progressively develop a more detailed closure plan, including closure criteria.
- Meet the requirements for the agreed land use for each domain.
- Provide for safe and geotechnically stable final landforms.
- Ensure beneficial use of water resources for downstream existing users and aquatic ecosystems is not compromised.
- Provide the local communities with long-term, sustainable opportunities following mine closure in the form of transferred skills and self-sustaining community development programs.

- Provide long-term surveillance, monitoring and maintenance of key domains including the open-pit and downstream assessment points.
- Agree to transfer assets (and liabilities) to a third party for sustainable, long-term management including monitoring and maintenance.

8.3 Conceptual Completion Criteria

Completion criteria are measures of the achievement of closure objectives. The criteria supported by measurable parameters will provide an agreed set of environmental and social indicators that, when met, will demonstrate successful rehabilitation and closure. Meeting the completion criteria (as indicated by implementation of an appropriate monitoring program (see Chapter 12)) will demonstrate that the rehabilitated landscape has met the overall objectives and can be handed back to the appropriate stakeholders.

There are two types of completion criteria: design and construction criteria (leading indicators) and outcome or performance criteria (lagging indicators). Both are required for successful closure and relinquishment. The different purposes of these criteria are as follows:

- Design and construction criteria articulate the design intent and the design parameters that should be measured during the construction and quality assurance process respectively.
- Outcome criteria provide measurable indicators of closure success.

Completion criteria will be further developed to be consistent with the SMART (specific, measurable, achievable, relevant and time bound) principles, and to reflect the principle of sustainable development. This will be based on results of further research and ongoing monitoring and in consultation with relevant stakeholders.

The process for developing completion criteria will consist of the following:

- Determine the specific ways in which the land and water will be used in consultation with stakeholders, and define how the rehabilitated area needs to perform to support this use.
- Develop detailed designs that meet the basis of design criteria and land and water use requirements.
- Evaluate the likely outcome of the designs through quantitative assessments (e.g., modelling) and determine whether closure is likely to achieve the required performance standards for the desired end land and water use.
- Revise designs if necessary and identify the criteria that will need to be measured to ensure that construction achieves the design specifications and associated performance objectives.
- Use appropriate assessment techniques and site monitoring data associated with progressive rehabilitation to develop performance criteria for the rehabilitated areas.
- Monitor the performance of the constructed designs and review the performance criteria.
- Develop remedial action plans where monitoring indicates that performance criteria are not being achieved.

Draft conceptual completion criteria that are applicable for the entire site are outlined in Table 8.1. Draft conceptual completion criteria for specific domains are provided in Chapter 10. These will be refined based on experienced and knowledge gained during construction and operation and through the completion of targeted closure investigations.

Table 8.1 Draft site-wide conceptual completion criteria for the project

Closure Objective	Draft Conceptual Completion Criteria	Indicator
Provide an agreed process for the planning, validation and reporting of decommissioning and rehabilitation activities.	Closure plan, designs, criteria and monitoring plans meet all regulatory requirements.	Regulatory approvals.
	Closure plan is reviewed on a three-yearly basis and amended where required.	Evidence of subsequent iterations of report.
Consult with internal and external stakeholders to progressively develop a more detailed closure plan, including completion criteria.	Form and implement a closure steering committee at least 10 years prior to decommissioning with various internal and external stakeholders.	Evidence of committee formation and stakeholder consultation records and agreement on closure plans.
	Maintain relationships with the community, landholders and other stakeholders and continue consultation regarding mine closure planning activities.	Stakeholder consultation records.
Provide the local communities with long-term, sustainable opportunities following mine closure.	Meet the agreed end land and water use, which provide opportunities for local communities to maintain their sustainable livelihood.	Records from community consultation indicate that the site has identifiable beneficial uses in the long term.

8.4 Governance Framework

FRL recognises the material risk and associated responsibility for managing produced mine waste rock and tailings, and engineered facilities such as dams to contain them. Accordingly, the company and its parent company PanAust has established a comprehensive governance framework that encompasses organisational resourcing, systems and processes to support its sustainable business model. An overview of the governance framework is shown in Figure 8.1.

Considering the responsibility for mine waste will need to be integrated into the FRHEP by closure, aspects relating to waste rock and tailings management are discussed here for completeness.

8.4.1 Tailings Review Committee

PanAust's Managing Director has instituted a Tailings Review Committee (TRC) whose membership includes the Managing Director, internal experts on tailings engineering and risk management, and executives with organisational accountability for facility planning, design, construction and operation.

The objectives of the TRC are to:

- Inform the Managing Director of material risks associated with the facilities and the appropriateness and effectiveness of action plans intended to mitigate the identified risks.
- Oversee the implementation of actions related to material risk management and continuous improvement in relation to facility management.
- Ensure that the TIRP completes annual reviews of the design, construction, operation and closure of facilities.
- Provide executive management support and associated resources for identified actions arising from TIRP reviews.

- Evaluate the plans proposed by operational management to act on matters arising from the TIRP reviews to ensure that they are appropriate, practical and make efficient use of resources and funds
- Update the relevant risk registers for each business unit annually.

The TRC performs an important stewardship function, enables executive accountability and demonstrates commitment to the responsible management of PanAust's facilities.

8.4.2 Tailings Independent Review Panel (TIRP)

The TIRP is an important element of PanAust's and FRL's governance program. The TIRP comprises eminent experts in the disciplines of tailings, geotechnical engineering and water who collectively provide independent review and advice on material risks that may arise during the design, construction, operations and closure of the company's facilities. The TIRP's membership is expanded, as needed, to draw on specialist expertise in disciplines such as hydropower generation.

The TIRP members must not have any conflict of interest issues and must not be involved in any other work for PanAust's operations that would require review by the TIRP. TIRP members must also be independent from the day-to-day operations and design activities.

The TIRP conduct annual facility inspections and provide independent confirmation to the Managing Director that the company's facilities are being managed appropriately. Recommendations arising from the TRIP's reports are transferred to action plans that are monitored by the TRC. Responsibility for acceptance and implementation of the TIRP's advice and recommendations remains with PanAust and its nominated design consultants and construction contractors.

8.4.3 ARD Review Committee

High level governance of acid rock drainage (ARD) management is provided through PanAust's ARD Review Committee which comprises internal management and specialist external consultants. The committee verifies that management strategies are effective in limiting the potential for generation of ARD during construction and waste placement and that these strategies will continue to be effective following mine closure. Functions of the committee include to:

- Provide technical support to evaluate risks of operation of tailing storage facilities using the PanAust Enterprise Risk Management criteria.
- Highlight any new risk issues identified during the review period and ensure the risks are appropriately captured on the site risk register.
- Provide guidance on procedures that ensure ARD management and closure planning conform with international good practice and standards, legal requirements and operating licenses.
- Review the geochemical aspects of the tailings, waste rock and construction materials, particularly with respect to ARD and the potential for metalliferous leaching.
- Provide input on design, construction, operational and closure activities that may have long-term stability or other critical performance implications on ARD management.
- Review health, safety, environmental and social risks associated with ARD management and ensure they are appropriately addressed in accordance with design, construction, operation and closure plans.

Use of best practice water dam and tailings dam guidelines
Use of conservative design and operating assumptions
Risk assessment and failure mode effects analysis
Stakeholder input
Routine inspections, monitoring and QA/QC

Tailings Independent Review Panel
Tailings Review Committee
ARD Review Committee

Corporate accountability by Board and Managing Director
FRHEP General Manager
- Operations Manager
- Maintenance Manager
- Support Manager
Engineer of Record
- Design Leads
FRCGP Chief Operating Officer
- General Manager Operations

Design review
Comprehensive dam safety reviews
Dam safety inspections

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Figure No: 8.1

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8.4.4 Organisational Responsibility

The overall responsibility for closure of the FRCGP will lie with the Executive General Manager Frieda River. Environmental and social aspects of closure will be the responsibility of the Safety, Health, Environment and Emergency Response (SHEER) Manager and Community Relations (CR) Manager who will report to the General Manager of Operations and Government and Community Relations respectively.

The management and updating of the closure plan will be the responsibility of the SHEER Manager.

At the corporate and site level, a clear understanding of the scenarios that exist for post-mining operation of the hydroelectric power facility and ISF is required along with systems for ensuring long term management of dam safety after the mine closes. This will include, investigating opportunities to transfer key FRCGP responsibilities such as post closure open-pit water treatment, continued containment of the waste rock and tailings within the ISF, and downstream water quality. The long-term stewardship of the ISF is a critical element of closure planning for the FRCGP and a key concern of stakeholders. FRL has already commenced this stewardship program through the development of the Tailings Independent Review Panel (TIRP). Overall stewardship of the ISF will lie with the FRHEP and as such it is not covered by this closure plan, however the FRCGP will be a key stakeholder in closure planning for the ISF.

Key positions of responsibility in terms of the FRHEP are the An Engineer of Record (EOR) and FRHEP Manager.

The EOR is the approver of all designs, as-built construction, operations and performance monitoring of the FRHEP including the embankment. The overarching responsibility of the EOR is to determine if the FRHEP meets applicable regulations, guidelines and standards. To execute this responsibility, the EOR must be completely familiar with the design, history and current conditions of the embankment. Where the EOR is also the designer of record, involved through construction and operations, this knowledge would be implicit in the design, as-built, monitoring and inspection reports. Given the complexity of the FRHEP, the EOR will need to rely on other qualified professional engineers to provide assurances of ancillary facilities related to the hydropower structures, including the diversion and spillway structures.

The FRHEP Manager will be ultimately responsible for all day-to day operations of FRHEP and tailings and waste disposal, and ultimately decommissioning activities. All functional leads at the FRHEP will report to the FRHEP Manager, as well as the Tailings and Waste Leads from the mine.

8.4.5 Assurance

Independent qualified professionals provide assurances related to water management, tailings and waste stability, waste geochemistry and water quality.

Design Review

Facility designs are subject to a stage gated review and approval process. Designs are typically peer reviewed by a group of internal specialists and/or external independent experts to confirm that the design can be released to the next, more detailed, stage of work.

Routine Inspection and Monitoring

Daily, weekly and monthly inspections and monitoring is performed by trained employees reporting to the site based FRHEP Manager. Monitoring of dam seepage and embankment deformation is undertaken along with inspections and audit programs to ensure that monitoring

equipment is operational and functioning correctly. The EOR reviews the inspection and monitoring reports monthly.

Quarterly inspections are performed by PanAust's corporate Principal Tailings Engineer and/or Senior Tailings Engineer.

Quality Control and Assurance

Site laboratories perform material testing for quality control and quality assurance of construction materials. The site laboratories are audited every two years by an independent auditor. Independent testing activities are undertaken at an accredited external laboratory for validation of quality control activities.

Dam Safety Inspections

PanAust engages competent and experienced consulting organisations to perform the role of Design Engineer. The appointed Design Engineer has responsibility for preparing engineered designs, as directed by company representatives, for approval by the EOR. An annual audit of each facility is conducted and documented by an independent expert engineer.

Comprehensive Dam Safety Reviews

Comprehensive dam safety reviews (CDSRs) were recently initiated. These reviews will be performed at five-yearly intervals and other critical project milestones. The reviews are undertaken by a "suitably qualified and experienced person in relation to high risk tailings dams", in accordance with the ANCOLD guidelines. The review is undertaken, as a minimum, based on the following key ANCOLD guidelines:

- Guidelines on Dam Safety Management (ANCOLD, 2003)
- Guidelines on the Consequence Categories for Dams (ANCOLD, 2012a)
- Guidelines on Tailings Dams, Planning, Design, Construction, Operation and Closure (ANCOLD, 2012b).

8.5 Post Mining Land Use

At mine closure, it is envisioned that the FRCGP area will contain a mix of agricultural land, forested areas, waterways (including lakes), and some unproductive areas (former mining areas including the Ok Binai waste dump, and HITEK open-pit), potentially with some remaining infrastructure to support community development (see Section 6).

Specific goals for post mining land uses are to:

- Make cleared areas available for safe, sustainable and productive use as far as practicable for income generation and livelihood support of local communities.
- Encourage biodiversity and conservation outcomes for areas that have not been cleared or are unlikely to be suitable for productive purposes. This includes support of self-sustaining vegetation that is consistent with surrounding natural areas.
- Implement land uses that will be supported by, owned and managed by the government or other third parties.
- Provide support for impacted communities in the form of transferred skills and self-sustaining community development programs.

The following options have been identified as post mining land uses for the site:

- Biodiversity conservation areas.

- Agriculture production (i.e., food crops) and plantation forests (i.e., timber production).
- Non-timber forest products including fruits and vegetables or grasses.
- Unproductive land use (i.e., former mine areas unsuitable for productive uses).
- Community infrastructure to be investigated as an opportunity.

To ensure that planned mine closure activities are consistent with the final land use(s), FRL will identify and implement an agreed alternate end land use(s) that minimises or eliminates restrictions on future potential uses.

It will be important to identify and agree upon an end land use(s) with stakeholders early in the closure planning stages, as it is likely that this will impact on the way decommissioning and rehabilitation planning is to be undertaken. It is acknowledged that identifying and agreeing to suitable end land uses is a significant piece of work that remains to be completed.

This work will require that FRL:

- Undertake, in consultation with relevant stakeholders, a detailed end land use options study.
- Assess potential post mining land uses, the risks and opportunities and cost, practicality and methods to achieve each land use.
- Conduct stakeholder engagement and consultation with regards to selected land use options.
- Update the closure plan to reflect agreed end land uses.

Most importantly, FRL may come to an agreement to transfer some infrastructure to a third party if this is mutually beneficial and is safe. This will feature in a key role within decisions to retain infrastructure. Once infrastructure has been relinquished, FRL will have no obligation for upkeep or associated safety liabilities.

9. DECOMMISSIONING AND REHABILITATION

This section of the plan provides a summary of the rehabilitation principles that FRL intends to use during closure of the FRCGP. These include principles that provide the basis for decommissioning and continued rehabilitation over the life of mine.

9.1 Planning

Planning activities will include the:

- Undertaking of detailed post mining land use study mentioned in Section 8.5 to assess potential post mining land uses, the risks and opportunities, and cost, practicality and methods to achieve each land use.
- Development and periodic updating of the Rehabilitation Management Plan.
- Development of implementation schedules and specific 'domain'-based rehabilitation plans to guide the execution of rehabilitation activities or activities to achieve the selected end land use.
- Clear delineation of all areas that will be disturbed during the mine life and the timing of their rehabilitation or methods to achieve the selected end land use.
- Transfer of infrastructure to a third party, if this is mutually beneficial and can be adequately maintained. This will include preparation of asset management plans.

9.2 Transfer of Assets

FRL may come to an agreement to transfer infrastructure to a third party, if this is mutually beneficial and can be adequately maintained so that ongoing post-closure activities such as periodic monitoring and maintenance of permanent structures can be sustained for the life of the structures. This will be determined with relevant stakeholders to ensure that prerequisite approvals have been obtained prior to closure and that any associated liabilities are clearly understood and agreed at the point of transfer.

At the end of the mine life, fixed infrastructure and mobile equipment will be either decommissioned and demolished or divested to a third party. All assets have management requirements associated with them and the recipient of a transferred asset should have a full understanding of these management requirements and associated liabilities.

As the site moves towards closure an asset management plan will be developed which includes:

- An asset register with associated risk assessment.
- Clear understanding of stakeholder preferences determined through ongoing consultation.
- Demolition or divestment plans for each asset, including approval and contractual requirements.
- Procedures for demolition or divestment.

9.3 Decommissioning

9.3.1 Demolition and Disposal

Once mining operations have ceased (and including the transfer of any assets), decommissioning will commence and is expected to take three years. This will involve the removal of infrastructure,

facilities, equipment and services, unless otherwise agreed with stakeholders. Following the cessation of operations, the following steps will be undertaken:

- Remove mobile equipment.
- Dismantle or demolish FRGCP assets which are not required after relinquishment. This includes remaining equipment, infrastructure and services.
- Remove salvageable materials (e.g., steel, tanks) from site and sell as scrap for recycling where it is economic to do so. Such materials will probably include items such as steel pipework, framework, beams and sheeting.
- Remove and dispose of non-salvageable, non-contaminated materials in designated landfill/s or void/s. Such materials will probably include concrete foundations, miscellaneous building materials and tyres.
- Fracture concrete structures and foundations where there is no post mine land use for the structure or foundations to promote infiltration and then cover this with NAF material.
- Incinerate hazardous materials such as hydrocarbons.
- Leave in situ cabling and pipework located at depths greater than 600 mm below the final ground surface.
- Complete final profiling of waste management facility and other landforms.
- Flush, depressurise or empty (or other decommissioning) sub-surface services (e.g., compressed air, water and concentrate pipelines) which will not result in adverse environmental impacts if left in place.
- Plug and cap all subsurface pipelines.
- Revegetate landforms to meet the agreed final land use, closure objectives, completion criteria and closure indicators, after consultation with stakeholders.

These steps will be subject to future modification based on further consultation with stakeholders, refinement undertaken by FRL's closure planning team and results of progressive rehabilitation.

9.3.2 Hazardous Materials

Incorrect disposal of potentially contaminating or hazardous materials and chemicals may cause pollution, health and social concerns for the employees and surrounding communities. Potentially contaminating and hazardous materials comprise items such as waste hydrocarbons or chemicals and unused hydrocarbons and process chemicals sourced from mine facilities including the explosives magazine facility, mechanical workshop, and fuel storage spaces. At decommissioning, hazardous materials will be managed in accordance with the environmental management system. Specific measures will include:

- Dispose industrial wastes in an on-site, CEPA-approved landfill constructed by FRL, which will be used primarily for flammable and putrescible wastes.
- Incinerate oil and oily waste material in the on-site, CEPA-approved incineration facility.
- Excavate any ground contaminated by hydrocarbons and remediate the land.
- Remove hazardous and industrial wastes from site by a licensed contractor, where appropriate.

A contaminated land assessment of project components will be undertaken at the decommissioning stage of the FRCGP. In the event that contaminated soils remain at closure, their extent will be determined via a site investigation and they will be remediated accordingly. All contaminated materials will either be removed for off-site disposal or else treated prior to on-site disposal in landfill.

9.4 General Rehabilitation

Rehabilitation generally comprises two stages: landform design and the reconstruction of a stable land surface, and the revegetation or development of an alternative land use on the reconstructed landform. The main objectives of rehabilitation are to:

- Physically stabilise the land so that it is safe and erosion is controlled.
- Leave final landforms with a surface upon which vegetation can be successfully established.
- Revegetate landforms to meet the agreed final land use.
- Ensure that drainage is of acceptable quality.
- Protect adjacent undisturbed ecosystems.

9.4.1 Soil Management

While areas disturbed by the FRCGP will require some rehabilitation during mining operations including along the access roads and spoil dumps, as is the case for most mining projects like this, the majority of rehabilitation for such areas will occur once mining has ceased. A description of soil resources within the FRCGP area are outlined in Section 3.2.3.

Topsoil salvaged during land clearing could be used to cover disturbed areas and to serve as a growth medium for the re-establishment of vegetation; however, stockpiling of soils for extended periods can have adverse impacts on microbiological activity in the stored soils and, therefore, compromise the re-establishment of vegetation at mine closure. This, in combination with the long mine life, high rainfall environment and steep terrain, means that topsoil stockpiles are generally not practicable. Furthermore, the area required to create temporary stockpiles would increase the footprint of the Project.

In some instances where topsoil reuse is available for rehabilitation, methods of reusing topsoils will include direct topsoil return. This involves the stripping of topsoil and immediate respreading on disturbed areas. Alternatively, if appropriate areas for direct return of topsoil are unavailable (which will be the most likely situation), the possibility of stockpiling topsoil in well-drained areas in a stockpile height not exceeding 2 m, and being revegetated as soon as practicable, will be investigated.

The high rainfall and growth rates of many plant species in the Project area suggests that natural colonisation of plants, particularly small disturbance areas, may be sufficient from a rehabilitation perspective. The likely success of natural regeneration, however, will be highly dependent on the underlying substrate in the disturbance area and the adjacent vegetation type. FRL will conduct revegetation trials on a variety of soils and topsoil/waste rock blends throughout the mine life.

In each case, surface ripping across the land surface contours to a depth of approximately 50 cm will be undertaken to alleviate compaction or the natural strength of the substrate, which would otherwise hinder successful vegetation growth.

9.4.2 Erosion and Sediment Control

A detailed erosion and sediment control management plan will be prepared as part of the FRCGP's environmental management and monitoring plan prior to the commencement of construction activities. This plan will describe measures to control and minimise soil erosion and sedimentation (and associated environmental impacts) due to FRCGP activities.

The primary objective for the erosion and sediment control management plan will be to limit erosion and then to capture coarse sediment in drainage from disturbed areas. These principles will apply to the planning, design, construction, operation and decommissioning of the FRCGP. These measures are likely to focus on sediment sources (e.g., soil disturbance) and the sediment pathway (e.g., watercourses) to limit coarse sediment reaching the Frieda River and its tributaries; it is generally not possible to prevent fugitive fine sediment in a setting such as the mine site. These measures are likely to include a combination of:

- Designing drainage systems for the life of the mine and the final mine geometry to create a landform that allows free drainage of surface runoff while limiting erosion.
- Controlling sediment sources by reducing fugitive sediment generated. This may be achieved with progressive rehabilitation and by separating impacted and non-impacted runoff. Diversion channels around the various mine facilities will be used wherever possible.

Measures to reduce erosion and sediment transport during the decommissioning and closure of the FRCGP will include:

- Limiting the area of soil disturbed and exposed to erosion.
- Rehabilitating disturbed lands progressively, where practicable.
- Maintaining erosion and control measures during decommissioning earthworks.

9.4.3 Landform Design

Landscape rehabilitation (where appropriate for the agreed end land use) is likely to include some, or all, of the following items (dependent on the location):

- Reprofiling the ground surface to original or stable contours and surface drainage lines.
- Scarifying compacted soils along the contours, particularly in heavily trafficked areas.
- Applying brush matting, mulching or compost to all prepared surfaces to assist with moisture retention and erosion control.

All constructed landforms will be designed and constructed to form safe and stable landforms, recognising the locally steep terrain and high rainfall of the mine area.

9.4.4 Revegetation

Where appropriate, rehabilitation and revegetation strategies developed will aim to create conditions that favour the formation of vegetation communities through natural processes. Initial stabilisation of rehabilitation areas using quick-growing groundcovers will reduce the erosive impacts of rainfall and surface water flow. Once groundcover plants are established, shade trees will be established to develop a dense canopy since many native forest species require shade for successful colonisation.

FRL's approach to revegetation involves:

- Developing a rehabilitation and revegetation program to meet the desired end land use.
- Rehabilitating disturbed land as soon as it is no longer required for FRCGP activities, where practicable. Initial emphasis will be on land stabilisation to limit erosion, with end land use being a longer-term priority.

Where necessary, sites will be prepared by:

- Deep-ripping areas of compacted soil.
- Reprofiling to create a safe and stable landform.
- Spreading any available topsoil (on appropriate areas).

- Contour furrowing or ripping respread areas.

Rehabilitation likely involve two main revegetation methods: direct seeding or natural regeneration. Trials will also investigate other methods including direct planting.

Direct seeding involves broadcast seeding of native seed mixes across disturbed areas, using the remaining substrates as a growth medium. Local endemic primary coloniser species, which are short-lived but prolific seed producers, will be important in revegetation. Generally a 'nursery' crop will be planted to provide initial protection and to stabilise the prepared surface (especially in the high-rainfall environment) while more permanent plants are becoming established. These will include local native pioneer species and nitrogen-fixing plants. Seeds, seedlings and cuttings will be collected from surrounding forested areas for revegetation and to link with surrounding habitat to assist recruitment into rehabilitated areas.

Natural regeneration of disturbed areas relies on the colonisation of disturbed areas by plant species, where seeds or other plant propagates have been spread by natural vectors such as wind and animal scats. This method may be improved by undertaking site preparation including deep-ripping of soils and reprofiling the surface to create a safe and stable landform. Following an improvement in substrate conditions brought on by pioneer species growth, the initial vegetation community is then succeeded by longer-lived species suited to the more stable conditions. This process, which can take a relatively long time compared to other rehabilitation methods, continues until a steady state vegetation community has been established. The high rainfall and growth rates of many plant species in the mine area suggests that natural colonisation of plants, particularly small disturbance areas, may be sufficient from a rehabilitation perspective. The likely success of natural regeneration, however, will be highly dependent on the underlying substrate in the disturbance area and the adjacent vegetation type.

Flora species will be used that reflect the overall rehabilitation and revegetation objectives to meet the desired end land use, i.e., growth, survival and regeneration. Factors that will be considered to determine the species mix include:

- Role of species in pre-existing vegetation communities.
- Results from field trials.
- Likelihood of reintroduction.
- Availability of seed or cuttings.
- Likely speed of germination and plant establishment.
- Propagules originating from local area.

9.4.5 Progressive Rehabilitation

FRL proposes to undertake progressive rehabilitation where possible. As many of the Project domains will not be readily available for substantial progressive rehabilitation during the operations phase of the mine, most rehabilitation will occur once production ceases and decommissioning begins.

It is proposed that regeneration and/or revegetation will be progressively completed when the areas become available. These include:

- Areas where material has been sidecast during road construction, subject to safety considerations.
- Areas around infrastructure sites once complete, for example construction camps that are no longer required.
- Road verges, exposed walls, benches and slopes.

- Recovered laydown areas and construction tracks.
- Spoil dumps and temporary stockpile areas.

The FRCGP's rehabilitation program will be developed in stages to facilitate the development of area-specific rehabilitation plans, as detailed below.

Progressive rehabilitation will also facilitate the trial of a range of rehabilitation procedures and processes throughout the operational life of the mine. This will include establishment of revegetation guidelines, which can be used to further refine and improve the success of closure rehabilitation. The two main revegetation methods that are likely to be used are: direct planting (e.g., via planting seeds, seedlings or plants) and facilitated natural regeneration.

Methods used for progressive rehabilitation are the same as those described for general revegetation in Section 9.3.4.

Progressive rehabilitation during operations will include site preparation, plant selection, timing, weed control, and monitoring and maintenance considerations. Detailed rehabilitation plans will be developed prior to construction.

9.4.6 Weed Control

Weed species may compete with target species in rehabilitated areas. Given that the majority of the FRCGP area is free of weeds (to date, weeds observed are benign, have low invasive capacities and present a negligible threat to conservation status), the presence of invasive weeds will need to be managed in order to meet completion criteria. Weed control, therefore, is a likely requirement of the rehabilitation program during operation, decommissioning and post decommissioning (see Chapter 12). Management measures include:

- Ensuring that project vehicles and equipment arrive on the mine site clean and free of soil, seeds and vegetative matter by inspecting vehicles and washing (where necessary) prior to being loaded on to barges for transport to site.
- Monitoring areas with high potential for susceptibility to weed invasion, such as along roadsides, recently cleared areas and newly rehabilitated areas, at regular intervals.

These measures will be detailed in the FRGCP's environmental management and monitoring plan as part of a weed, pest and disease management plan.

10. CLOSURE STRATEGY

The PanAust Group internal processes require that projects commence planning for closure from the earliest stages of project development. Such planning aims to clearly identify the appropriate closure options and future land uses that limit long term environmental and socio-economic risks. Multi-disciplinary teams develop, review and implement closure plans. These teams typically include experts in environmental management, engineering, community affairs, human resources and finance. Closure plans increase in detail and understanding improves as the site progresses towards closure.

10.1 Overview

A range of end land uses are expected to exist following the closure of the FRCGP. These are likely to include areas for biodiversity conservation, agriculture production, timber and non-timber forest products, and unproductive land (see Section 8.5).

For the purposes of describing the closure strategy and closure actions proposed for the FRCGP, facilities have been divided into eight domains. Each domain was separated based on similarities with regards to closure planning and end land uses (still to be clearly defined). Each domain will be treated as a separate entity for subsequent detailed work plans to be developed, but integrated into the overall plan to address common issues such as rehabilitation techniques.

Domains for the FRCGP are:

- Open-pit and quarries.
- Mining infrastructure.
- Ok Binai and limestone quarry waste dumps.
- Tailings pipeline and waste barging facilities.
- Transmission line and substation.
- Access and infrastructure corridor.
- Vanimo Ocean Port.
- Ancillary infrastructure.

In developing the closure strategy for each of these domains, consideration was given to appropriate end land use, as well as the technical feasibility of the suggested closure plans. Where practicable, disturbed land will be returned to self-sustaining vegetation. A preliminary description of the proposed end land uses for each domain is described in Table 10.1. These land uses are suggested preliminary feasible options.

Table 10.1 Proposed end land uses for each closure domain

Domains	Project Component	Preliminary Proposed End Land Use Option
Open-pit and quarries	• Open-pit. • Quarries.	Open-pit lake with exposed high walls and a pit lake (of poor water quality) surrounded by rehabilitated landscape similar to surrounding vegetation. Quarries are likely to remain as permanent landscape components. Some quarries may have an associated quarry lake.

Domains	Project Component	Preliminary Proposed End Land Use Option
Mine infrastructure	• ROM and primary crushing facility. • Mine infrastructure area. • Ore conveyor system and crushed ore stockpile. • Process plant. • Explosives magazine. • Raw water pipeline. • Environmental facility (landfill)	Infrastructure will be decommissioned and removed where possible. Rehabilitated landscape that is similar to surrounding vegetation.
Ok Binai and limestone quarry waste dumps and spoil dumps	• Ok Binai waste dump. • Limestone quarry waste dump.	Rehabilitated landscape that mimics recovery after a natural landslip.
Tailings pipeline and waste barging facilities	• Tailings pipeline. • Waste barging and loading facilities.	Infrastructure will be decommissioned and removed where possible.
Transmission line and substation	• Transmission line. • Substation.	Infrastructure will be decommissioned and removed where possible. Rehabilitated landscape that is similar to surrounding vegetation. Opportunities to transfer or sale will be investigated.
Access and infrastructure corridor	• Mine access road. • Link road. • Concentrate pipeline.	At relinquishment, roads will be transferred to the FRHEP to allow continued access to the ISF and powerhouse. Concentrate pipeline, fuel pipelines and raw water pipeline will be decommissioned and removed where necessary.
Vanimo Ocean Port	• Concentrate export facility. • Vanimo infrastructure area.	Concentrate export infrastructure will be decommissioned and removed where possible. Vanimo infrastructure area facilities will be decommissioned and likely transferred to a third party. Land rehabilitated to meet future land use as agreed with Vanimo Ocean Port operator.
Ancillary infrastructure	• Accommodation villages. • Administration building. • Green River facilities. • Communications. • Emergency facilities.	Accommodation villages, administration infrastructure and other ancillary facilities will be decommissioned and removed. Rehabilitated landscape that is similar to surrounding vegetation

The proposed plans are described in more detail in this section for each domain. It must be emphasised that these plans are notional and are subject to ongoing review during operation as the Closure Plan is progressively refined through consultation with relevant stakeholders, taking into account additional information obtained about environmental and other constraints as the FRCGP is developed.

As outlined in the PanAust Closure Standard, the development of a closure strategy will involve a process whereby closure options are identified, and a preferred option selected through stakeholder engagement with custodial parties. In addition, the strategy will refine the completion

criteria and performance indicators which, when they are met, will be used to demonstrate that the site is ready for custodial transfer (relinquishment).

10.2 Domain 1: Open-pit and Quarries

10.2.1 Description of Domain

A summary description of the open-pit and quarries is provided in Table 10.2 and its location shown in Figure 10.1.

Table 10.2 Description of Domain 1 – open-pit and quarries

Component	Description
Open-pit	• The HITEK open-pit will remain a permanent landscape feature and, as such, the final disturbance area of the open-pit will be approximately 720 ha (including haul and access roads).
Quarries	• Two quarries are proposed within the mine area with areas of disturbance estimated to be 28 ha and 10 ha, respectively.

10.2.2 Conceptual Closure Plans

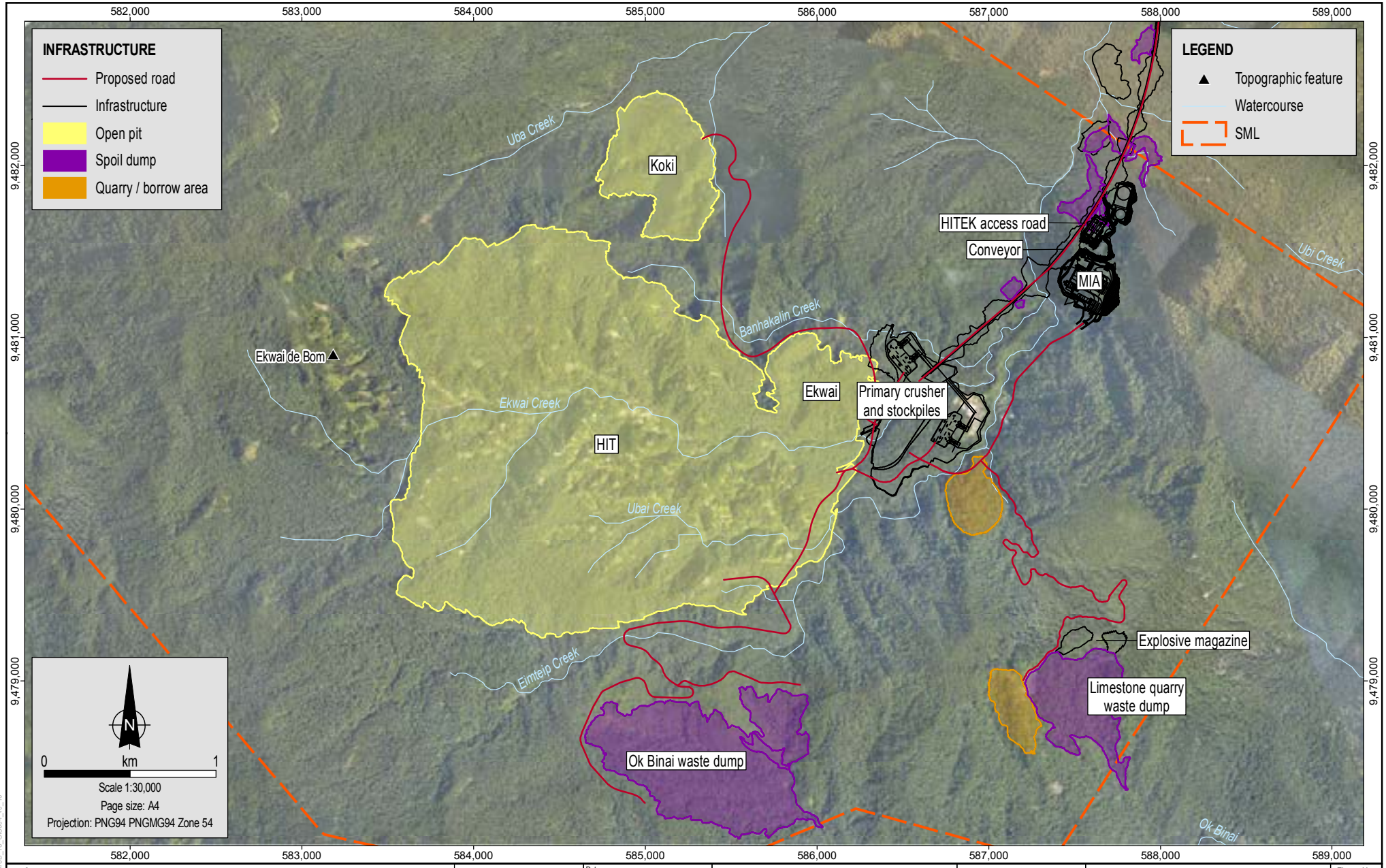
Open-pit

There are limited practical options for closure of an open-pit of this size in an area with steep terrain and high rainfall. FRL does not intend to backfill the open-pit because:

- The waste rock and tailings will be placed in the ISF for subaqueous storage to limit the potential for acid generation.
- Backfilling may sterilise the resource, should future commodity prices make it economical to mine further.
- The costs associated with backfilling would be prohibitive.

Following completion of mining operations, the open-pit will be allowed to flood to approximately RL 440 m when pumping from the open-pit sump stops. The water level in the final void will rapidly rise to approximately RL 450 m, which will be the elevation of the open-pit overflow on the northwestern side of the open-pit. To provide surge capacity and equalise flows throughout the year, the open-pit lake elevation would be maintained at about RL 440 m. At this level, there will be a high wall approximately 600 m in height exposed above the water level. Under average climatic conditions the open-pit is expected flood within three years assuming the diversion drains around the pit are directed into the open-pit to accelerate filling. When fully formed, the open-pit lake will cover approximately 40% of the surface area of the final open-pit.

The majority of the open-pit area exposed above the open-pit lake will be PAF and have high to very high capacity for acid generation. It can therefore be expected that acidic drainage will be produced within the final open-pit void post closure. The rates of sulphide oxidation and acid generation will slow in the longer term as sulphidic surfaces are progressively oxidised. This, in turn, will result in changes in open-pit runoff chemistry. The overall rate of change will not only depend on the initial sulphide content and the assumed rate of oxidation, but also any erosion or instability of the open-pit surface that leads to exposure of fresh, unoxidised rock.



Source:
Infrastructure, roads and tenements from FRL.
Villages, topographic features, watercourses and water bodies from FRL and Coffey.
Aerial imagery from FRL (captured 2011).
Hillshade DEM from SRTM.

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Date: 16.08.2018
Project: 754-ENAUABTF11575A
File Name: 11575_18_F10.01_GIS

Frieda River Limited

Sepik Development Project

FRIEDA RIVER

Mine area

Figure No: **10.1**

MXD Reference: 11575B_18_GIS004_v0_10

Water Balance

Upon cessation of mining activities, the HITEK open-pit will be inundated, and dewatering pumps will be stopped (i.e., year 34). Water balance modelling for the closure period were completed by SRK Consulting to assess the hydrological effects following the cessation of mining. With diversions around the HITEK open-pit maintained, the water balance model predicts that the open-pit will be flooded within three years after cessation of dewatering assuming the diversion drains around the pit are directed into the open-pit to accelerate filling.

Figure 10.2 shows the water movement around the mine site upon closure. Chapter 8 of the EIS (Coffey, 2018) details the expected water quality during closure.

Water management

Once the final void fills, excess water will be treated prior to discharge to Ubai Creek. Based on the exposure of the different types of rock comprising the open-pit walls on closure, modelling of expected open-pit water quality indicates that, once the open-pit has been allowed to fill to its discharge elevation, the water that will accumulate in the open-pit lake will remain acidic and contain elevated concentrations of metals (similar to those predicted during operation). Open-pit lake water will therefore be unsuitable for release and it has been assumed that water treatment prior to discharge will be required for the long term.

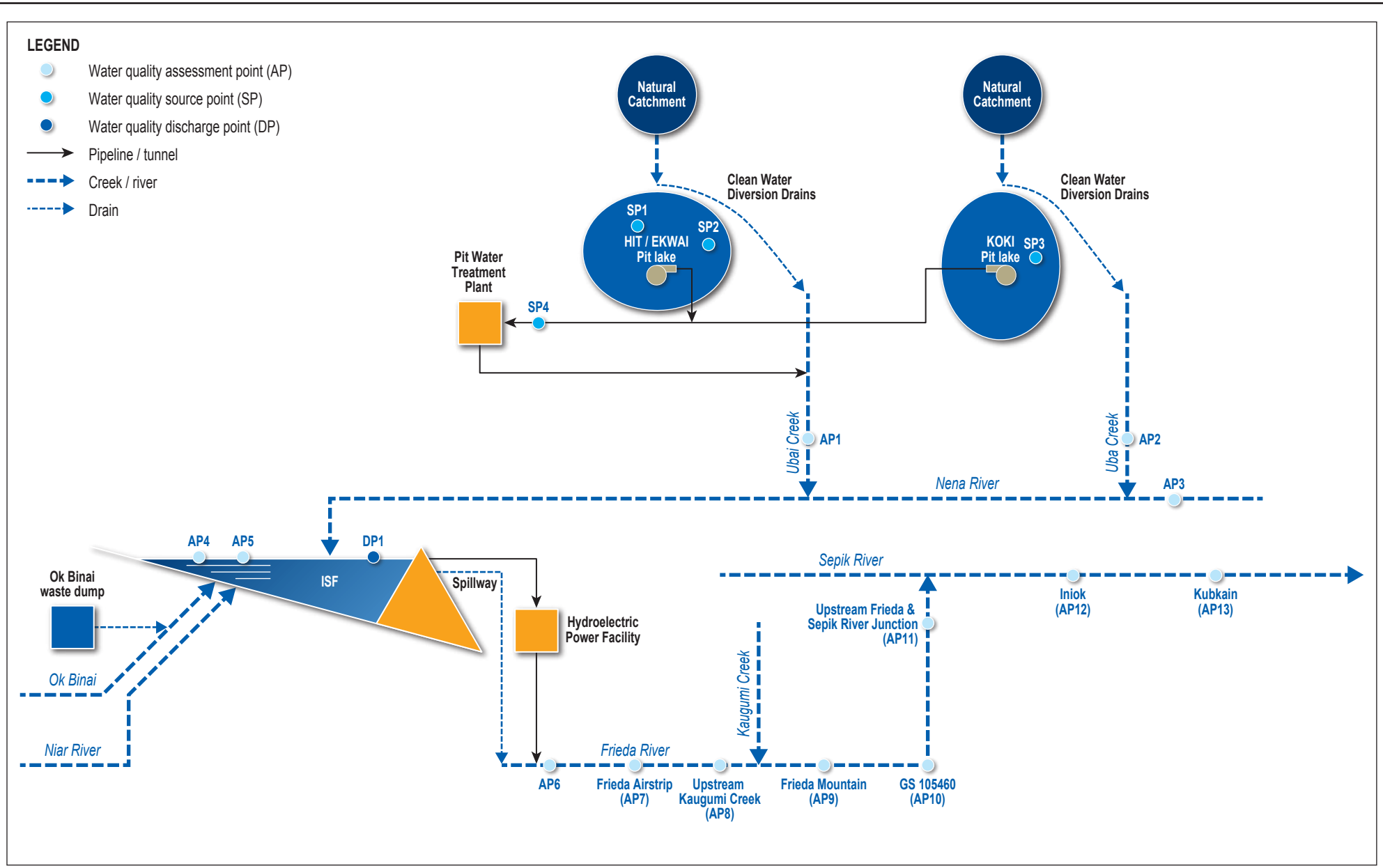
The open-pit water quality is expected to be poor due to the exposure of PAF material in sections of the open-pit walls as well as the presence of PAF material located on the mined benches, and subsequent generation of AMD. Water transferred from the open-pit sumps will be treated with lime to neutralise acidity and precipitate metals. Treated water will then be released to Ubai Creek, from where it will flow into the ISF and be subject to significant dilution prior to entering the downstream environment. The water treatment solids (sludge of metalliferous precipitates) will be disposed to the final void. After the open-pit lake stabilises, only the wall rocks above the lake elevation will contribute ongoing solute loadings. As a result the volume of lime required is predicted to decrease to 38 tonnes per day (from to 74 tonnes per day during the latter stages of operations).

Diversion drains will be maintained to divert clean runoff around the final void.

The duration over which treatment will be required post closure cannot be accurately predicted as it will depend on the rate of erosion of the wall rocks (exposing fresh materials) and the possibility of wall rock failures that will expose large areas of unoxidised material. The HITEK open-pit is likely to remain a source of AMD for many years after closure. Based on the sulphide depletion calculations, the rate of oxidation of the exposed wall rocks (and thus solute generation) could decrease by ~85% - 90% within the 50-year period. However, this does not consider regeneration of reactive surfaces by erosion and wall rock failure.

There are many examples of open-pit mines where metal leaching and acid generation has been occurring for many years post cessation of operations (e.g. Bougainville Mine ~ 20 years; Britannia Beach Mine, ~45 years, etc.) and it is anticipated that water treatment will be required for several decades after mining is completed at the site.

It is currently proposed that active water treatment for all open-pit water will be required throughout the life of the mine and continue for at least 50 years after mine closure to ensure downstream water quality criteria are met. With the implementation of the proposed water treatment and other control measures, the site is predicted to remain in compliance with the PNG Environment (Water Quality) Regulations (2002) and PNG Drinking water guidelines downstream of the proposed mixing zone during operations and after closure.



Source: FRL, 2016

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Project: 754-ENAUABTF11575B
File Name: 11575_18_F10.02_GRA

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Conceptual mine water balance schematic - FRCGP closure

Figure No: 10.2

AI Reference: 11575_18_GRA003.ai_3

A strategy to monitor open-pit water quality and hydrology/hydrogeology during operation will be developed to inform alternative closure options, which will be evaluated against the current scenario of treatment prior to discharge. A key part of this strategy will be further investigation of the erosivity factor for the final open-pit walls. Should the current scenario remain the preferred option, the monitoring data will be used as a basis for the final design of the treatment plant.

Where the perimeter of the open-pit can be accessed an earthen safety bund will be constructed. The bund will be constructed using competent rock to approximately 4 m wide and 2 m high. Due to the size of the ultimate open-pit perimeter and remoteness of the site and distances from the nearest communities, no fencing is planned to prevent access by animals and the public.

Warning signage (in English, Tok Pisin and local languages) will be placed at regular intervals to inform people of the risks of accessing the open-pit void, particularly in areas where safety bunding cannot be constructed. Discussion of community safety issues, particularly with regards to the open-pit lake, will be undertaken as part of the closure stakeholder engagement process.

All disturbed areas around the open-pit will be ripped and, where available, topsoil will be spread over the area to allow for an appropriate seed bed to ensure that regrowth of vegetation occurs (see Section 9.3.4).

Quarries

At decommissioning, quarries will be reprofiled to a stable grade and exposed areas will be allowed to regenerate. Quarries required for maintenance of the access road will remain active during the closure period. If any quarries form a lake, the quality of this water will be monitored to ensure any overtopping water is suitable for release to the downstream environment. In the event this is not the case, simple water treatment will be implemented. Most quarries are likely to remain as permanent landscape components.

Where the perimeter of the quarries can be accessed, an earthen safety bund will be constructed. The bund will be constructed using competent rock to approximately 4 m wide and 2 m high. Warning signage (in English, Tok Pisin and local languages) will be placed at regular intervals to inform people of the risks of accessing the quarry void, particularly in areas where safety bunding cannot be constructed (e.g., inaccessible areas above high walls).

10.2.3 Conceptual Completion Criteria

As discussed in Section 8.3, completion criteria are measures of the achievement of closure objectives. Meeting the completion criteria will demonstrate that the rehabilitated landscape has met the overall objectives and can be handed back to the appropriate stakeholders. Draft conceptual completion criteria for the open-pit and quarries domain are provided in Table 10.3. These will be refined based on experienced and knowledge gained during construction and operation and through the completion of targeted closure investigations.

Table 10.3 Draft conceptual completion criteria for open-pit and quarries

Component	Conceptual Completion Criteria
Provide for safe and geotechnically stable final landforms i.e., open-pit walls.	• Open-pit walls at closure meet the acceptable final design criteria as demonstrated by third party geotechnical assessment and reporting. • Safety signage installed around open-pit to prevent people from inadvertently accessing the open-pit. • Open-pit ramps are blocked to prevent inadvertent access. • Awareness program regarding open-pit safety has been completed at Social Catchment 1A villages as demonstrated by stakeholder consultation reports.

Component	Conceptual Completion Criteria
Ensure beneficial use of water resources for existing users and aquatic ecosystems is not compromised.	• Acidic open-pit lake water is treated to ensure discharge water is of acceptable quality for selected end land use at an appropriate monitoring locations, as demonstrated by water quality monitoring.
Surface water drainage control measures are installed and meet design criteria.	• Evidence of maintenance (and repair if necessary) to constructed designs of surface water diversion drains around the open-pit.

10.3 Domain 2: Mine Infrastructure

10.3.1 Description of Domain

A summary description of the mine infrastructure is provided in Table 10.4.

Table 10.4 Description of Domain 2 – mine infrastructure

Component	Description
ROM and Primary crushing facility and stockpiles	Primary crushing ore from the mine will be delivered to the ROM pad, which will have two identical 380 m^3 capacity ROM pockets that gravity feed ore into gyratory primary crushing units. This will cover approximately 23 ha.
Mine infrastructure area	The mine infrastructure area will include a variety of workshops, warehouses, bulk fuel storage, washdown bay, laydown areas, hydrocarbon storage facilities, and administration buildings and will cover approximately 15 ha.
Conveyor system	The conveyor system (49 ha) will transfer ore from the primary crushing facility to a covered crushed ore which will then be conveyed to the process plant.
Process plant	Process plant (33 ha) will consist primary grinding, re-grinding and flotation circuits; concentrate thickener, storage tanks and pumping station; and reagent storage facility and distribution system.
Explosives magazine	Located near a tributary of Nena River (Uba Creek) upstream of the Nena River's confluence with Ubai Creek. The facilities will include bulk explosive storage and preparation pad, explosives storage magazine, access roads between each area and a high-security 3 m-high perimeter fence.
Raw water supply	Raw water will be sourced from the ISF at a rate of approximately 3,800 cubic metres per hour (m^3/h) for ore processing and general non-potable consumption. Potable water will be sourced from the Nena River upstream of the ISF and pumped to the site accommodation village along the roads where feasible.
Environmental waste management facility and landfill	Environmental waste management facility will consist of an unrestricted waste covered area, restricted waste covered area, scrap metal area for both ferrous and non-ferrous scrap metal, composting area with bunkers for collection of compost material, tyre shredding facility, self-bunded diesel storage tank and environmental facility offices. There will also be a landfill facility.

10.3.2 Conceptual Closure Plans

ROM and Primary Crushing Facility

At decommissioning, the primary crushing facility will be demolished, with steel being recycled off site and other material being disposed in the final open-pit void. Due to its size the primary crusher dump pocket will remain in a safe and stable condition.

Concrete footings, slabs and hardstand areas will either be demolished, removed (see Section 9.2.1) to the ground surface and disposed within the open-pit void or fractured to allow infiltration and covered. Areas containing hydrocarbon contamination (for example around the concentrator and fuel storages) will be identified and remediated prior to disposal managed as per Section 9.2.2. Once the infrastructure has been removed from the area, the site will be ripped as required and rehabilitated using methods described in Section 9.3.4.

Once all stockpiles have been removed from the area, the site will be ripped and rehabilitated using methods described in Section 9.3.4.

Mine Infrastructure Area and Process Plant

At decommissioning, all infrastructure at the mine infrastructure area and process plant will be demolished, including administrative buildings, workshops, water and sewage treatment plants, fuel storage areas and warehouses, unless other options are agreed to with stakeholders. Non-hazardous waste will be disposed of within the open-pit void.

Demolition will entail the termination of services and the controlled removal of all structures. All services (i.e., electricity, water and sewage) will be disconnected to ensure safe demolition of buildings. For the purposes of this plan, it has been conservatively assumed that buildings will not be dismantled for reuse and that controlled demolition of all structures will be undertaken.

All concrete footings, slabs and hardstand areas will be demolished and removed to the ground surface or fractured to allow infiltration and covered with growth medium. Concrete waste and building rubble will be disposed of in the final open-pit void. Areas containing hydrocarbon (or reagent) contamination will be identified and remediated prior to disposal, with the specific method of hydrocarbon remediation being determined via trials to be undertaken during operation.

For areas where concrete slabs and hardstand areas have been removed, the area will be ripped to reduce compaction and will then be shaped to be free draining with regards to surface runoff, where available.

The stockpile area will be scalped to remove PAF material as guided by the contaminated land assessment (likely to be in the order 1 to 2 m), which will be disposed of in the ISF.

Conveyor System

Overland sections of the conveyor will be dismantled. Prior to demolishing, the conveyor will be removed and cut into sections and disposed in an appropriate manner. The supporting frame will be demolished and salvageable material transported off site for recycling. Where spillage of rock and ore has taken place along the conveyor, contaminated areas will be remediated or removed and disposed of in the open-pit void or ISF.

Explosives Magazine

At decommissioning, the security permitter fence will be removed and the explosives storage magazine will be demolished, with steel being recycled off site and other material being disposed of appropriately. All concrete footings, slabs and hardstand areas will be demolished and removed (see Section 9.2.1) to the ground surface and disposed within the open-pit void. Areas containing any residual contamination will be identified and remediated prior to disposal managed as per Section 9.2.2.

Raw Water Pipeline

Above-ground sections of the carbon steel water pipelines running from the Nena River, upstream of Ubai Creek, and the ISF, will be either recycled off site, left in situ or disposed of in an appropriate manner.

Internal Roads

Most internal roads will be ripped to reduce compaction and then shaped to be free draining with regards to surface runoff. Following site preparation these areas will be direct seeded using appropriate seed stock to ensure that regrowth of vegetation occurs. The mine access road and link road will remain active to provide access for FRHEP operations.

The link road will be maintained during the closure monitoring period to allow access to the accommodation village, water treatment plant and downstream monitoring locations. These roads will be transferred to the FRHEP at relinquishment.

Environmental Facility

At the cessation of mining the landfill will be rehabilitated (i.e., capped) such that leachate production is reduced. The design and construction of the capped landfill will be in accordance with the Environmental Code of Practice for Sanitary Landfill Sites, PNG (2001).

10.3.3 Conceptual Completion Criteria

Draft conceptual completion criteria for the mine infrastructure domain are provided in Table 10.5. These will be refined based on experience and knowledge gained during construction and operation and through the completion of targeted closure investigations.

Table 10.5 Draft conceptual completion criteria mine infrastructure

Component	Conceptual Completion Criteria
Provide for safe and geotechnically stable final landforms.	• Following rehabilitation, a site contamination survey conducted to Australian Standards demonstrates that all areas of contamination have been remediated successfully. • The final rehabilitated areas meet the agreed end land use.
Ensure beneficial use of water resources for existing users and aquatic ecosystems is not compromised.	• All landforms are free draining except where specific structures (i.e., drains) have been constructed. • Erosion is limited in extent and comparable to other areas off site, demonstrated through the use of reference sites. • Surface water drainage control measures are installed and meet design criteria.
Provide for resilient and self-sustaining ecosystems and landscape function	• Self-sustaining vegetation is growing on previously disturbed areas around the open-pit, as evidenced by vegetation monitoring. • Vegetative cover is increasing and on a trajectory to achieve in excess of 70% of foliage cover. • Evidence that nutrient cycling is occurring and the presence of leaf litter is assisting in limiting erosion of the soil/spoil surface.

10.4 Domain 3: Ok Binai and Limestone Quarry Waste Dumps

10.4.1 Description of Domain

A summary description of the Ok Binai and limestone quarry waste dumps and NAF waste rock management is provided in Table 10.6 and location shown in Figure 10.1.

Table 10.6 Description of Domain 3 – Ok Binai and limestone quarry waste dumps

Component	Description
Ok Binai waste dump	An eroding waste dump will be established in the Ok Binai catchment to receive organic waste and topsoil from the pre-strip of the HITEK open-pit. NAF waste rock extracted during Year -1 prior to construction of the conveyor will also be placed in this dump. The waste dump is expected to receive 14 Mt of organic waste and topsoil, and 3.4 Mt of NAF waste rock. A haul road will be developed during construction to provide life of mine access between the open-pit and the Ok Binai waste dump. The material will be dumped into the Ok Binai Valley from an elevated ridgeline. Once construction of the conveyor is completed in Year -1 waste rock will be subaqueously deposited in the ISF.
Limestone quarry waste dump	The limestone quarry waste dump will be an eroding dump into the Ok Binai catchment. This dump will commence construction approximately two years prior to impoundment of the ISF (during Year -4) and will receive spoil from construction of nearby infrastructure such as the primary crusher, access roads and haul roads. The limestone quarry waste dump will receive approximately 10 Mt of spoil over two years. Once impoundment occurs, fugitive sediment will report to the ISF.

10.4.2 Conceptual Closure Plans

Ok Binai and Limestone Quarry Waste Dumps

The Ok Binai and limestone quarry waste dumps will both be eroding waste rock dumps that will be located in the Ok Binai valley. The Ok Binai waste dump will comprise primarily soils and pre-strip generated at development of the open-pit, and then during subsequent push backs. The limestone quarry waste dump will comprise spoil from construction of nearby infrastructure. The dumps will continually erode and will result in the transport of sediment to the Ok Binai which will then be carried into the ISF within a relatively isolated zone of the lake.

Given that the waste dumps will be eroding and therefore geotechnically unstable it will not be safe nor practical to actively rehabilitate the waste dumps. The dumps are expected to gradually erode over a period of 22 years, i.e., until approximately Year 20 of operations. After this point natural revegetation would be expected much as occurs after a natural landslide, although this may be limited due the scouring and the lack of substrates for vegetation to establish on.

10.4.3 Conceptual Completion Criteria

Draft conceptual completion criteria for the Ok Binai and limestone quarry waste dumps domain are provided in Table 10.7. These will be refined based on experience and knowledge gained during construction and operation and through the completion of targeted closure investigations.

Table 10.7 Draft conceptual completion criteria for the Ok Binai and limestone quarry waste dumps

Component	Conceptual Completion Criteria
Provide safety awareness for the Ok Binai and limestone quarry waste dumps.	• Safety signage installed around the Ok Binai and limestone quarry waste dumps to prevent people from inadvertently accessing the unstable landform. • Awareness program regarding safety has been completed at Social Catchment 1A villages as demonstrated by stakeholder consultation reports. • Waste dumps are geochemically stable, and erosion and natural revegetation is comparable to a natural landslip.

10.5 Domain 4: Tailings pipeline and waste barging facilities

10.5.1 Description of Domain

A summary description of the tailings and waste rock management is provided in Table 10. Mine waste rock and process tailings will be stored subaqueously in the ISF which is designed in accordance with safety guidelines outlined in the Australian National Committee on Large Dams (ANCOLD) guidelines.

Table 10.8 Description of Domain 4 – Tailings pipeline and waste barging facilities

Component	Description
Tailings pipeline	Final tailings will be thickened and pumped via a dedicated pipeline from the process plant for subaqueous storage in the ISF. The pipeline will be a 10 km floating system with a carbon steel section and a high-density polyethylene pipe section. Tailings will be deposited in uniform layers via a tremie pipe supported by a relocatable deposition pontoon. Wastes and tailings will be deposited into three compartments: the Nena compartment, the Ok Binai compartment and the Frieda compartment.
Waste barging and loading facilities	All NAF and PAF waste rock will be transferred via a conveyor belt from the mine to the barge-loading facility. The barge loading facility will be a single fixed location for the life of the mine (Figure 1.2). At the barge loading station, the waste rock will be loaded into 5,000 t barges. The barges will transport and deposit the waste rock via a barge latching system for subaqueous storage in the ISF.

10.5.2 Conceptual Closure Plans

The ISF has the capacity to store a maximum of 3.5 Bm^3 (approximately 4.9 billion tonnes (Bt)) of waste rock and tailings. At closure, a permanent water cover with a depth of at least 20 m will be maintained over the waste rock and tailings to preclude oxidation of the material into the future.

Tailings pipeline and waste barging/loading facilities

Associated tailings and waste rock barging infrastructure will be permanently decommissioned and disposed of in an appropriate manner. These closure activities will include:

- Flushing and removal of tailings disposal pipeline and associated infrastructure.
- Infrastructure (including pipelines and conveyors) will be either recycled off site, left in situ or disposed of in an appropriate manner.
- Removal of barges and barge loading infrastructure.

10.5.3 Conceptual Completion Criteria

Draft conceptual completion criteria for the tailings pipeline and waste barging facilities domain are provided in Table 10.9. These will be refined based on experience and knowledge gained during construction and operation and through the completion of targeted closure investigations.

Table 10.9 Draft conceptual completion criteria for tailings pipeline and waste barging facilities

Component	Conceptual Completion Criteria
Provide for safe and non-hazardous final rehabilitated areas	• Following rehabilitation, a site contamination survey (conducted to Australian Standards) demonstrates that all areas of contamination of been remediated successfully. • The final rehabilitated areas meet the agreed end land use. • All infrastructure is removed unless the item is required for an end land use as demonstrated by an audit against the final closure plan.
Provide for resilient and self-sustaining ecosystems and landscape function	• Self-sustaining vegetation is growing on previously disturbed areas, as evidenced by vegetation monitoring. • Vegetative cover is increasing and on a trajectory to achieve in excess of 70% of foliage cover. • Evidence that nutrient cycling is occurring and the presence of leaf litter is assisting in limiting erosion of the soil/spoil surface.

10.6 Domain 5: Transmission line and substation

10.6.1 Description of Domain

A summary description of the transmission line and substation domain is provided in Table 10.10.

Table 10.10 Description of Domain 5 – Transmission line and substation

Component	Description
Transmission Line	Hydroelectric power from the FRHEP to the mine site will be supplied by a 22-km, 132 kV overhead power transmission line. The electricity transmission line system will generally follow the link road to the process plant.
Substation	The main high voltage (HV) substation will be located at the process plant. Power will be distributed through 132/33 kV overhead lines and buried cables. Various medium voltage (MV) substations throughout the process plant will be supplied with 33 kV power by a feeder originating from the process plant main MV substation. Overhead distribution lines will reticulate power from the process plant MV substations to the following facilities: • Site accommodation village. • Administration and training. • Explosives storage. • Mine infrastructure area. • Waste management facilities.

10.6.2 Conceptual Closure Plans

At relinquishment, the transmission line and substation will likely be transferred to the third-party power distributor that operates the Northern Transmission Line. As such no completion criteria are proposed.

10.7 Domain 6: Access and Infrastructure Corridor

10.7.1 Description of Domain

A summary description of the access and infrastructure corridor domain is provided in Table 10.11.

Table 10.11 Description of Domain 6 – Access and Infrastructure Corridor

Component	Description
Access roads (including the mine access road)	FRCGP private access roads include: • Mine access road - a 39 km mine access road from Hotmin to the mine (unsealed 7.5-m-wide dual lane). • HITEK access road – a 6-km-long, dual-lane, unsealed road (nominally 7.5 m wide) will run parallel with the overland conveyor from the site accommodation village to the HITEK open-pit. • Haul road - an unsealed 7-km-long dual lane road with a formation width (road reserve) of 40 m and a road carriageway of 29 m, suitable for 240 t dump trucks. The main haul road will be developed during construction to provide life of mine access between the open-pit and the Ok Binai waste dump. The haul road will also transport ore from the open-pit to the ROM pad. The mine access road and the link road, will connect the construction camp, accommodation villages, process plant, HITEK open-pit and ISF.
Concentrate pipeline	The concentrate pipeline (approximately 325 km in length) will run from the process plant to Vanimo Ocean Port. The pipeline will be carbon steel and will be installed with an internal HDPE liner and external polyethylene coating. The concentrate pipeline will generally follow the main access road along the infrastructure corridor to minimise disturbance and provide access to the pipeline.

10.7.2 Conceptual Closure Plans

Access Roads

The mine access road and the link road will be maintained during the closure monitoring period to allow access to the water treatment plant and downstream monitoring locations. These roads will be transferred to the FRHEP at relinquishment. The mine access road and the link road, will require regular maintenance while active.

At decommissioning, all roads that are not required for ongoing monitoring and maintenance will be ripped to reduce compaction and then shaped to be free draining with regards to surface runoff. Following site preparation these areas will be direct seeded using appropriate seed stock to ensure that regrowth of vegetation occurs.

Concentrate Pipeline

Prior to closure, the concentrate pipeline will be flushed with water to ensure that all concentrate is recovered. Since this pipeline will be buried these are expected to remain stable after decommissioning and hence will remain in situ. Being buried, any environmental and safety hazards associated with the deterioration of the pipeline will be mitigated and any unnecessary adverse environmental effects (e.g., local ground and vegetation disturbance) associated with pipe recovery will be avoided.

The remaining sections of above-ground pipeline (e.g., on bridges for river crossing) will be removed. The pipeline will be cut where it enters underground sections and the various above-ground sections cut into smaller pieces and removed from site for recycling. The sections of the remaining pipeline will be sealed off where cut to avoid access.

Infrastructure associated with the concentrate pipeline, including storage tanks, pump stations, monitoring stations and inspections wells, will be demolished, removed and rehabilitated. Any remaining concrete structures and foundations will be broken up or fractured to promote water infiltration, and will be covered with soil.

10.7.3 Conceptual Completion Criteria

Draft conceptual completion criteria for the access domain are provided in Table 10.12. These will be refined based on experience and knowledge gained during construction and operation and through the completion of targeted closure investigations.

Table 10.12 Draft conceptual completion criteria for access and infrastructure corridor

Component	Description
Provide for safe and geotechnically stable final landforms	• Following rehabilitation, a site contamination survey conducted to Australian Standards demonstrates that all areas of contamination have been remediated successfully. • The final rehabilitated areas meet the agreed end land use. • All infrastructure is removed unless item is required for an end land use as demonstrated by an audit against the final closure plan.
Ensure beneficial use of water resources for existing users and aquatic ecosystems is not compromised	• All landforms are free draining except where specific structures have been constructed. • Erosion is limited in extent and comparable to other areas off site (demonstrated through the use of reference sites). • Surface water drainage control measures are installed and meet design criteria.
Provide for resilient and self-sustaining ecosystems and landscape function	• Self-sustaining vegetation is growing on previously disturbed areas, as evidenced by vegetation monitoring. • Vegetative cover is increasing and on a trajectory to achieve in excess of 70% of foliage cover. • Evidence that nutrient cycling is occurring and the presence of leaf litter is assisting in limiting erosion of the soil/spoil surface.

10.8 Domain 7: Vanimo Ocean Port

10.8.1 Description of Domain

A summary description of the Vanimo Ocean Port domain is provided in Table 10.13.

Table 10.13 Description of Domain 7 – Vanimo Ocean Port

Component	Description
Concentrate export facility	A new concentrate export facility will be located at the Vanimo Ocean Port. Concentrate will be discharged from the pipeline, dewatered, stored and loaded to ocean-going vessels for shipment to overseas markets (see Figure 1.1).
Vanimo infrastructure area	Consisting of an industrial area located adjacent to the main access road. The Vanimo infrastructure area will include FRLs regional office, permanent accommodation, warehouse and laydown yard, freight storage, maintenance workshop, bulk diesel storage tanks and a waste management facility.

10.8.2 Conceptual Closure Plans

The concentrate export facility will include a concentrate thickener and filter plant, concentrate storage shed, ship loading facility, water treatment plant, bulk diesel pipeline and diesel generators.

At closure, it is expected that the ship loading facility and wharves will continue to be operated and managed by the third party. It is planned that at decommissioning, the concentrate handling and storage facilities will be demolished, unless a third-party agreement can be established by the end of the mine life.

With respect to the Vanimo infrastructure area, given the location of these facilities there may be opportunities to retain components (or the facilities in their entirety) and sold to a third party for future use. If a third-party agreement cannot be established by the end of the mine life, all infrastructure will be demolished and the area rehabilitated to agreed standards.

For the purposes of this plan, it has been conservatively assumed that buildings will not be dismantled for reuse and that controlled collapse of all structures will be undertaken. Where appropriate, steel will be sold for reuse or exported off site for recycling, while all other material will be disposed of in an appropriate manner.

All concrete footings, slabs and hardstand areas will be demolished and removed to the ground surface.

10.8.3 Conceptual Completion Criteria

Draft conceptual completion criteria for the Vanimo Ocean Port domain are provided in Table 10.14. These will be refined based on experience and knowledge gained during construction and operation and through the completion of targeted closure investigations.

Table 10.14 Draft conceptual completion criteria for Vanimo Ocean Port

Component	Description
Provide for safe and geotechnically stable final landforms.	• Following rehabilitation, a site contamination survey (conducted to Australian Standards) demonstrates that all areas of contamination of been remediated successfully. • The final rehabilitated areas meet the agreed end land use. • All infrastructure is removed unless item is required for an end land use as demonstrated by an audit against the final closure plan.

10.9 Domain 7: Ancillary infrastructure

10.9.1 Description of Domain

A summary description of the ancillary infrastructure domain including Green River facilities, accommodation facilities, and communications is provided in Table 10.15.

Table 10.15 Description of Domain 8 – Ancillary infrastructure

Component	Description
Accommodation and administration facility	Located on the mine access road between the process plant and the HITEK open-pit.
Green River facilities	Will consist a bus terminal facility will be located adjacent to the airport terminal and a concentrate pump station.
Communications	A high-capacity microwave network will be installed and will carry fixed line and cellular telephone, satellite services, data and radio via a wide area network. Communications will be distributed throughout the project area via local area networks and distributed via the overhead electricity transmission infrastructure. Several radio repeater towers will be located between the mine site and the Vanimo Ocean Port.

Component	Description
Emergency power facilities	Emergency power will be supplied via a 30 MV capacity diesel generator power station located at the site accommodation village to mine site facilities. Power facilities include: • 12 containerised 2.5 MVA diesel generator sets. • Bulk fuel storage facility containing six 75,000 L self-bunded tanks. These self-bunded fuel tanks will be located at the open-pit, quarry sites, waste barging facility and emergency diesel generators.
Communications	A continuous optical ground wire (OPGW) conductor will be provided on all 33 kV distribution lines each containing a minimum of 24 core single mode fibres.

10.9.2 Conceptual Closure Plans

Ancillary infrastructure

The remainder of ancillary infrastructure including accommodation facilities will be decommissioned following the cessation of processing. At decommissioning, electricity, water and sewage services will be disconnected and accommodation buildings will be demolished.

For the purposes of this plan, it has been conservatively assumed that buildings will not be dismantled for reuse and that controlled collapse of all structures will be undertaken. Where appropriate, steel will be sold for reuse or exported off site for recycling, while all other material will be disposed of in an appropriate manner (such as within the final open-pit void).

All concrete footings, slabs and hardstand areas will be demolished and removed to the ground surface. For areas where infrastructure has been removed, the area will be ripped, shaped to be free draining and covered with topsoil, where available and rehabilitated to agreed standards.

Communications towers and ancillary infrastructure may be retained and operated by a third party to maintain communications to the area. If a third-party agreement cannot be established by the end of the mine life, all communications infrastructure will be demolished and the area rehabilitated to agreed standards.

10.9.3 Conceptual Completion Criteria

Draft conceptual completion criteria for the ancillary infrastructure domain are provided in Table 10.16. These will be refined based on experience and knowledge gained during construction and operation and through the completion of targeted closure investigations.

Table 10.16 Draft conceptual completion criteria for ancillary infrastructure

Component	Conceptual Completion Criteria
Provide for safe and geotechnically stable final landforms	• Following rehabilitation, a site contamination survey (conducted to Australian Standards) demonstrates that all areas of contamination of been remediated successfully. • The final rehabilitated areas meet the agreed end land use. • All infrastructure is removed unless item is required for an end land use as demonstrated by an audit against the final closure plan.
Ensure beneficial use of water resources for existing users and aquatic ecosystems is not compromised	• All landforms are free draining except where specific structures (i.e., drains) have been constructed. • Erosion is limited in extent and comparable to other areas off site (demonstrated through the use of reference sites). • Surface water drainage control measures are installed and meet design criteria.

Component	Conceptual Completion Criteria
Provide for resilient and self-sustaining ecosystems and landscape function	• Self-sustaining vegetation is growing on previously disturbed areas, as evidenced by vegetation monitoring. • Vegetative cover is increasing and on a trajectory to achieve in excess of 70% of foliage cover. • Evidence that nutrient cycling is occurring and the presence of leaf litter is assisting in limiting erosion of the soil/spoil surface.

10.10 Community Infrastructure and Development Programs

FRL recognises that its' social license to operate rests on community acceptance and approval of the project. FRL's objective is to secure a social license that is robust and can endure over the life of the project. Accordingly, FRL's vision is to:

> *Help develop skilful and healthy communities, including through the equitable and effective distribution of benefits, and in doing so provide a strong social license to operate.*

FRL's community development targets align with the United Nations' Sustainable Development Goals, which cover basic areas of human and social development.

The primary vehicle for determining community benefits from the project is the Development Forum and its resultant Memorandum of Agreement (MoA). The Minerals Resource Authority (MRA) hosts the Development Forum. Since the Development Forum occurs following the submission and in-principle approval of the EIS, details of the types of community benefits have not yet been negotiated.

The most important benefits generated through the project are likely to be:

- Business development opportunities generated by the project. This may include: support for the development of a Representative Company to participate in larger contracts with the project; and, advice, management and education services to the Frieda River community, particularly for women and disadvantaged groups, to facilitate the participation in smaller contracts and services. Goods and services will be sourced, in order of preference, from the priority catchment zones.
- Employment and training. During peak construction, the majority of workers required will be in semi-skilled and skilled roles to construct and build the mine infrastructure. During operational phase, less than 10% of the workforce is proposed to be expatriates with the remainder drawn from the local market. Operations will have in place a comprehensive training and development program to support local and regional employees become job ready and transition through the skills pipeline.
- Community development through funding of targeted development projects.

10.10.1 Workforce and Suppliers

During decommissioning and closure, the number of personnel employed at FRL will decrease with only a small maintenance team required on site until relinquishment. This decrease of the labour is a significant social risk during the closure process. To address this risk in advance of closure, FRL will prepare a Human Resources Plan that outlines retention strategies for necessary personnel and investigate alternative employment options for staff.

Retrenchments at the mine are likely to begin towards the end of the mine life, prior to closure. Although a formal retrenchment package has not yet been developed, this will reflect:

- Existing award rules concerning retrenchment entitlements.

- Applicable legislation.
- PNG mine closure policy and guidelines (MRA and DMPGM, 2015).

10.10.2 Community Transition

As outlined in the PanAust Group Closure Standard, operations will consider impacts of closure on the surrounding environment and communities, including locally employed staff, contractors and suppliers. Socio-economic mitigations implemented through the life of mine will address the potential for over-reliance on the operation and aim for sustainable programs which are self-sufficient following closure.

A socio-economic impact assessment (SIA) will be conducted at least five years prior to closure to complement the socio-economic baseline and impact assessment completed for the EIS. The SIA will provide a pre-closure baseline that can be used to develop social completion criteria with appropriate local performance indicators related to aspects such as health, education, household incomes and social harmony that can demonstrate positive legacies associated with mining.

Minimum standards for socio-economic planning for closure will consider:

- Direct and indirect impacts on landowners and socio-economic dependency on nearby communities.
- Handover plans for fixed assets, which have been identified as providing potential end use benefits, including municipal, financial and governance planning.
- Institutional planning for community development programs addressing social disadvantage such as health, education and micro-financing services. This will include management plans and resourcing for sustained delivery of services and phasing out of reliance on mine funding. The aim of these operational development plans should be to make the mine no longer necessary for the future successful operation of the programs.
- Development of programs to address artisanal mining and other community activities on and around the mine lease which could impact on mine closure sustainability.

10.10.3 Stakeholder Consultation

Relating to the stakeholder consultation principles outlined in Chapter 5, FRL will highlight closure issues such as management options for the open-pit lake, end land use and ongoing use of facilities and infrastructure when undertaking discussions with relevant parties, in particular the provincial government and local stakeholders. This will allow for interests and concerns to be raised and addressed during mine planning and provide sufficient time for local stakeholders to plan for mine closure.

Consultation will occur with relevant government agencies, local landowners and communities, and other stakeholders to ascertain what buildings, structures, equipment and facilities may be of ongoing benefit and could therefore be sold or left behind under agreed terms. The stakeholder consultation will take place as outlined in Chapter 5, but is likely to be refined during operations. Any such agreement will only be considered by FRL where public safety and environmental health is not compromised and the recipient has the financial, technical and other resources necessary to adequately manage, operate and maintain the infrastructure, both in the short and long term.

11. UNANTICIPATED MINE CLOSURE

Best practice closure planning requires consideration to be given to closure actions in the unlikely event of sudden or unplanned closure, as well as temporary closure. In such circumstances, the CEPA and MRA will be notified as soon as possible that the FRCGP is being placed in care and maintenance. This chapter details the process to be followed for sudden and temporary closure.

11.1 Sudden Closure

Sudden or unplanned closure would occur when mine construction or operation suddenly ceases due to factors such as financial constraints or non-conformance/s with regulatory requirements. Some of the closure objectives described in Section 8.2 could be met after sudden closure, although it would not be possible to meet others. Progressive implementation of closure plans minimises the adverse effects of sudden closure.

In the event of sudden closure, an accelerated closure process will occur. A decommissioning plan based on the pre-existing closure plan will be prepared and implemented by FRL, taking into account the site's non-operational status.

11.1.1 General

The following general site requirements would be completed under a sudden unplanned closure:

- Prepare and leave mechanical, hydraulic, electrical systems in a 'no-load' condition, and ensure that they are effectively isolated so that they cannot be restarted or tampered with.
- Drain all pipelines.
- Safely contain all petroleum, chemicals and explosive products.
- Seal, secure and/or lock all buildings.
- Construct fences/barriers as required to restrict access to specific areas within the site.
- Notify the appropriate local and government authorities.
- Designate a contact person(s) for authorised access to the site.
- Establish a program for roadway maintenance to ensure that access to the site is maintained.
- Continue regular inspections.
- Establish a schedule for the monitoring of ground and surface water, the open-pit lake and ISF reservoir.
- Assign an appropriately qualified person to review and report all monitoring data collected. Prepare a trigger, action, response plan (TARP) based on risk assessment that considers the possible impacts on the surrounding environment(s).

11.1.2 Open-pit

In addition to the rehabilitation and mine closure requirements described above, should sudden unplanned closure occur, the following rehabilitation and closure measures for the open-pit will need to be implemented:

- Continue regular inspections related to security around the void rim.
- Continue monitoring open-pit wall stability, particularly for the highwall.
- Continue pumping water from the open-pit to the water treatment plant.
- Continue water treatment to meet the adopted site discharge water quality standards.

It is assumed that the ore left in the stockpile area will be processed prior to unplanned closure and the area left as a hardstand area. If this is not the case, then residual ore will be placed back into the open-pit void or ISF.

11.1.3 Integrated Storage Facility

If the mine permanently closes before the end of the currently planned 33-year mine life, the tailings and waste levels would be lower than their respective designed final elevations. This difference would not require changes to the overall closure strategy as described in the next section.

11.2 Temporary Closure

Temporary closure (also known as care and maintenance) would occur when mine construction or operation temporarily ceases due to factors such as financial or operational constraints. Temporary closure is normally planned and would entail the immediate implementation of a care-and-maintenance program, taking into account the potential for future operations at the site. The care and maintenance program would contain key components that require continuous monitoring, including ongoing environmental and social monitoring programs.

In the event of temporary closure, a decommissioning plan based on the pre-existing closure plan will be prepared and implemented, taking into account the potential for future operations. Temporary closure will trigger a review of the final closure plan, which will be required to be implemented should circumstances remain adverse to reopening and operation.

In the event of temporary closure, continued water quality monitoring within and downstream of the ISF would be required. A decision would need to be made with respect to the floating tailings pipeline. At a minimum, the tailings pipes would be flushed. Should the suspension period be extended, the pipelines would be removed from the ISF and returned to a central storage yard, or secured against theft and damage.

Similarly, a decision will need to be taken as to the management of the barges. For a short suspension period, the barges would be moored and secured at a docking facility. For longer suspension periods, the barges would be removed to above the high-water mark and stored on dry land in a secure environment (fenced or in sheds). The barges would need to be prepared for extended storage by removing fuel etc. and following the manufacturers' directions.

Actions to be undertaken in the event of temporary closure will guide the decommissioning plan, but, at this stage, these will be similar to those described for sudden closure (see Section 11.1).

12. CLOSURE MONITORING, MAINTENANCE AND REPORTING

12.1 Monitoring and Reporting

The conceptual closure plan requires certain completion criteria to be met and FRL is committed to this requirement. A pivotal part of this process is a robust monitoring system based on completion criteria and indicators that provide evidence and assurance that rehabilitation has been successful (as defined by the agreed outcomes). The monitoring program will be dynamic, flexible and adaptive, able to respond to unexpected results. Much of the monitoring will be a continuation of the environmental and social monitoring program that will be conducted during operations.

The objectives of the closure environmental and social monitoring program will be to:

- Allow for comparison with pre-mining conditions and demonstrate that completion criteria have been met, prior to lease relinquishment.
- Demonstrate that the key environmental and social issues identified during closure planning have been effectively managed.
- Identify issues that require alternative or additional management measures.

It has been assumed that closure monitoring will be required until completion criteria have been met. The duration of further closure monitoring will be determined on a risk-based basis, with additional monitoring and remediation activities being required if the monitoring results do not demonstrate that completion criteria have been achieved.

This plan will be regularly updated and refined to reflect changes in project development and operational planning, as well as the environmental and social conditions and circumstances.

A conceptual closure monitoring program is presented in Table 12.1. The financial means to conduct this program will be sufficiently provisioned by FRL. Detailed completion criteria and indicators, which will be central to the monitoring program, will be developed and outlined in the subsequent revisions of this plan. Similarly, monitoring locations will be determined in subsequent revisions of this plan and in consultation with relevant stakeholders.

Table 12.1 Conceptual decommissioning and closure monitoring program

Component	Variables/Agreed Outcomes	Timing/Frequency
Meteorology	Basic parameters (e.g., wind, rainfall, temperature) to provide context for hydrology monitoring.	Continuation of operational program during and after decommissioning.
Hydrology	Water levels (stream gauging) to provide context to water quality and biological monitoring.	Continuation of operational program during and after decommissioning.
Stream sedimentation	Stream-bed cross sections to measure river bed aggradation or erosion and determine trends over time.	Continuation of operational program during and after decommissioning.
Hazardous materials	Records show that contaminated sites have been remediated appropriately.	Decommissioning.
Landfill inspection	Inspection for vermin, biological impacts, litter, odour and hygiene to ensure that landfills are left in a hygienic state.	Decommissioning.

Component	Variables/Agreed Outcomes	Timing/Frequency
Public safety	Visual inspection by the engineer to confirm that all excavations have either been backfilled or safety signage has been erected.	Decommissioning.
Geotechnical investigations for physical stability	To identify significant environmental or human safety risks during closure a visual inspection by geotechnical engineer will be undertaken to confirm that engineered structures have been completed as per design, and there are no signs of subsidence, slumping or slippage in the structure.	Decommissioning.
Stream water quality	Standard water quality measures (e.g., dissolved oxygen, pH, temperature, conductivity, turbidity, TSS, total and dissolved metals) to compare water quality during closure with baseline conditions and project-specific water quality criteria.	Continuation of operational program during and after decommissioning until completion criteria have been met.
Stream sediment quality	Standard stream sediment measures (e.g., particle size and metals) to compare sediment quality during closure with baseline conditions and project-specific sediment quality criteria.	Continuation of operational program during and after decommissioning until completion criteria have been met.
Water quality of ISF	Standard water quality measures (e.g., dissolved oxygen, pH, temperature, conductivity, turbidity, TSS, total and dissolved metals) to compare water quality during closure with project-specific water quality and beneficial use criteria, as well as to provide input to continued modelling of predicted water quality downstream of the ISF spillway.	Annually until completion criteria have been met.
Water quality of discharges from open-pit lake	Standard water quality measures (e.g., dissolved oxygen, pH, temperature, conductivity, turbidity, TSS, total and dissolved metals) to determine water treatment requirements if needed to ensure beneficial use criteria are met.	Annually until completion criteria have been met.
Aquatic fauna	Aquatic fauna sampling (e.g., abundance and tissue metal concentrations) to compare catch statistics and tissue metal levels during closure with those obtained during the baseline survey and operations, and determine trends over time. This will include aquatic fauna in the ISF for comparison against beneficial use criteria.	Continuation of operational program during and after decommissioning until completion criteria have been met.
Soil	Soil parameters, i.e., physical and chemical characteristics including surface stability (e.g., resistance to erosion), capacity to accept rainfall, nutrient status and ability to support plant growth.	Monitored during and following rehabilitation activities and compared to pre-mining conditions
Vegetation diversity and cover	Vegetation sampling to compare vegetation recovery during closure with baseline conditions and project-specific criteria.	Annually until two consecutive monitoring events indicate that criteria are being met or will likely be achieved.
Noxious weeds	Survey of noxious weeds surrounding disturbed areas prior to, during and following revegetation. To determine if weed control is required.	Annual until completion criteria have been met. If completion criteria are not met, continue to monitor annually until two consecutive monitoring events indicate that criteria are being met or will likely be achieved.

Component	Variables/Agreed Outcomes	Timing/Frequency
Pest animals	Survey of pest animals surrounding disturbed areas prior to, during and following revegetation. To determine occurrence of pest animals and if control is required.	Annual until completion criteria have been met. If completion criteria are not met, continue to monitor annually until two consecutive monitoring events indicate that criteria are being met or will likely be achieved.
Community health monitoring	Community health monitoring in order to assist in managing perceptions of the health of communities living in the former mine and infrastructure areas.	A minimum of 20 years after decommissioning.

12.2 Maintenance

Construction of final closure landforms will be followed by a period of monitoring prior to relinquishment of the site. During this time, the company will remain responsible for ongoing management including the provision of the required funds for the site including maintenance of the mine access road and open-pit lake water treatment plant, maintenance of surface drainage system, weed and vegetation management, and potentially repairs to any failed landforms. During this period a small maintenance workforce will be employed to conduct maintenance activities.

FRL will develop an appropriate funding and governance structure for post-closure maintenance and monitoring.

A detailed maintenance plan will be developed in the year prior to closure of the site, however it is expected to include the elements outlined in the section below.

12.2.1 Integrated Storage Facility

Detailed closure plans for the embankment containing the ISF are described in the FRHEP closure plan (Coffey, 2018).

The ISF will remain in place after mine closure and the hydroelectric power facility may continue to generate power for other users. The water downstream of the ISF will need to meet water quality standards. The ISF has been designed so that water in excess of 20 m depth will be maintained over the submerged waste material to preserve water quality. Maintaining the water cover will inhibit oxidation of tailings and waste rock and limit the potential for release of soluble contaminants.

When both the mine and the hydroelectric power facility close, the spillway gates will be removed, with water continuing to flow into the facility via direct rainfall and inflow from the upstream catchment, with excess water passing over the ungated spillway. The closure design flood will be the 72-hour probable maximum flood (PMF) and must be passed by the spillway even if the ISF is full of water or natural sediment.

12.2.2 Water Management

Routine maintenance of water management infrastructure will include:

- Ensuring that water treatment infrastructure is operated and maintained to the intended specification.
- Infrastructure controlling water discharges to the environment from the open-pit lake and water reservoirs. This may include weirs and dissipation structures.

- Diversion infrastructure directing water to, or from the open-pit lake, or water reservoirs. This may include removing vegetation and/or sediment to ensure the water management system remains as designed.
- Drainage infrastructure intended to manage erosion and infiltration is maintained.

Water discharged from the flooded open-pit lake will be treated prior to release to Ubai Creek until closure criteria are met. Regular post-closure monitoring and maintenance will be undertaken as completion criteria are progressively achieved and sustained.

12.2.3 Site access

Routine maintenance of the mine access road and the link road will be maintained during the closure monitoring period to allow access to the accommodation village, water treatment plant and downstream monitoring locations. These roads will be transferred to the FRHEP at relinquishment.

This will include ongoing road maintenance such as grading, filling holes and repairing damage to water management infrastructure.

12.2.4 Geotechnical

Routine maintenance of landforms with regards to geotechnical aspects will include:

- Repair the landforms to maintain the integrity of the cover.
- Repair of landforms should erosion rates exceed design specifications, for example after extreme rainfall events.

12.2.5 Rehabilitation

Rehabilitation maintenance may be required to:

- Control and prevent weed infestation while native vegetation becomes established.
- Improve soil nutrient levels where rehabilitation has failed.
- Control or repair erosion where rehabilitation has failed.

13. TIMELINE

A conceptual closure timeline for the FRCGP is shown in Appendix A. To demonstrate the likely timeline of all closure related activities, the timeline is divided into three components:

- **Closure planning,** which demonstrates the development of the closure plan over the life of the mine, key milestones for studies and resolution of assumptions.
- **Management precincts**, which demonstrate when closure of specific components will occur.
- **Management**, which demonstrates the commitment to closure management and monitoring.

14. GLOSSARY

The following terms and abbreviations are defined in the context in which they are used in this plan.

alluvial *adj.*	pertaining to material, such as sand or silt, deposited by running water (e.g., a creek or river).
biodiversity *n.*	the diversity of different species of plants, animals and microorganisms, including the genes they contain, in the ecosystem of which they are part.
bioregion *n.*	an area which constitutes an identifiable ecosystem in terms of geology, climate and biota.
clastic *n.*	relating to rock or rocks composed of fragments of older rocks.
colluvium *n.*	loose and incoherent deposits, typically at the foot of a slope or cliff line and formed by gravity.
cordillera *n.*	a series of more or less parallel ranges of mountains together with the intervening plateaux and basins.
decommissioning *n.*	the process of removing a facility from operation.
ecoregion *n.*	an area which constitutes an identifiable ecosystem in terms of geology, climate and biota.
epilimnion	the upper layer of water in a stratified lake system.
erosivity *n.*	is a measure of the potential ability of soil, regolith, or other weathered material to be eroded by rain, wind, or surface runoff.
groundwater *n.*	all waters occurring below the land surface; the upper surface of the soils saturated by groundwater in any particular area is called the water table.
lentic *n.*	standing or still water.
Malesia *n.*	a biogeographical region straddling the boundaries of the Indomalaya ecozone and Australasia ecozone, and also a phytogeographical floristic region.
potentially acid-forming *n.*	describes the acid forming capacity of material when exposed to oxygen and water.
porphyry *n.*	any igneous rock containing conspicuous phenocrysts in a fine-grained or aphanitic groundmass.
rehabilitation *n.*	restoration of environment to an agreed state.
scalped *v.*	removal of the soil and subsoil to a depth of at least 0.5 m.
stratovolcano *n.*	volcano consisting of layers of lava alternating with ash and pyroclastic rocks.

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Appendix A

Conceptual Closure Timeline

Conceptual Closure Timeline

	Feasibility, Planning and Design, and Construction	Operations (years)	Operations (years)	Decommissioning (years)		Closure monitoring and maintenance (years)				
	(6 years)	1 to 13	30 to 33	34	35	36	38	40	43	83
Planning										
Preliminary Closure Plan	■									
Closure materials inventory	■	■								
Geochemical characterisations		■	■							
Refinement of closure water balance and modelling		■	■							
Detailed Closure Plan		■								
Decommissioning plans			■							
Final Closure Plan			■							
Stakeholder consultation										
Review, revise and develop stakeholder consultation plan	■	■	■							
Closure steering committee meeting		■	■	■	■	■	■	■	■	
Stakeholder consultation	■	■	■	■	■	■	■	■	■	■
Progressive rehabilitation										
Develop, review and revise detailed rehabilitation plan	■	■								
Conduct rehabilitation research including suitable species		■	■	■	■					
Develop and maintain on-site nursery		■	■	■	■	■	■	■	■	
Progressive rehabilitation of construction camps		■								
Progressive rehabilitation of other available areas		■	■	■	■					
Review, refine and develop rehabilitation procedures and processes		■	■	■	■	■	■	■	■	
Human resources										
Identify on-site key roles and skills for closure		■	■							
A broader skills assessment of the workforce		■	■							
Development of workforce Human Resources Plan		■	■							
Employee assistance program	■	■	■	■	■	■	■	■	■	■
Community programs										
Review community support programs		■	■							
Conduct socio-economic impact assessment (SIA)			■							
Ongoing Support to Community Programs			■	■	■	■	■	■		

Conceptual Closure Timeline

	Feasibility, Planning and Design, and Construction	Operations (years)	Operations (years)	Decommissioning (years)		Closure monitoring and maintenance (years)				
	(6 years)	1 to 13	30 to 33	34	35	36	38	40	43	83
Decommissioning and Rehabilitation of Closure Domains										
Mine Void										
Open-pit including blocking ramp and constructing bunds				■						
Internal Haul Roads					■					
Pit Water Treatment Plant		■	■	■	■	■	■	■	■	■
Quarries				■						
Mine Infrastructure										
ROM and primary crushing facility				■						
Conveyor system and crushed ore stockpile				■						
Mine infrastructure area				■						
Process plant				■						
Raw water pipeline				■						
Explosives magazine				■						
Tailings pipeline and waste barging facilities										
Tailings pipeline				■						
Waste barging and loading facilities				■						
Transmission line and substation										
Transmission line				■						
Substation				■						
Access and infrastructure corridor										
Mine access road (maintenance)		■	■	■	■	■	■	■	■	■
Link road (maintenance)		■	■	■	■	■	■	■	■	■
Concentrate pipeline (above-ground features)					■					
Vanimo Ocean Port										
Concentrate export facility				■						
Vanimo industrial area				■						
Ancillary infrastructure										
Accommodation villages				■						
Adminstration building				■						
Green River facilities				■						
Management Provisions										
Development of unplanned closure plan	■	■								
Project Closure Environmental Monitoring				■	■	■	■	■	■	■
Project Management & Surveying				■	■	■	■	■	■	■
Maintenance of rehabilitated areas						■	■	■	■	■
Closure monitoring of outflow from ISF				■	■	■	■	■	■	■