



**FRIEDA RIVER**

Frieda River Limited

## **Sepik Development Project**

Environmental Impact Statement

Chapter 5 – Description of the Proposed Development

SDP-6-G-00-01-T-084-007





## **5. DESCRIPTION OF THE PROPOSED DEVELOPMENT**

The Project is located in the Sandaun and East Sepik provinces and comprises four interdependent components: FRCGP, FRHEP, SIP and SPGP (see Figure 1.5).

Section 5.1 of this chapter defines the Project area that encompasses these components, and Section 5.2 provides an overview of their key characteristics. Section 5.3 describes the requirement of the Project to resettle four villages. Section 5.4 outlines the indicative development schedule for the approval, detailed design, construction and operation of the Project. Sections 5.5 to 5.8 describe the main facilities and activities associated with each of the four project components and how they relate to each other. As the Project will be managed in accordance with FRLs policies and procedures, there are certain aspects that are common to all four components, including hazardous material management, workforce strategy, construction and operating standards, and waste management. These aspects are described in Sections 5.9 to 5.12.

The primary driver for the Project is the development of the HITEK porphyry copper-gold deposits that form the basis for the FRCGP. Due to the remote location and limited existing infrastructure in the region, the development of the mine will require significant investment in support infrastructure to provide the access, power and services necessary to operate the mine. Establishment of this support infrastructure also provides a development opportunity for the Sepik Region of PNG. The scope of the Project has therefore been designed to provide both an economically feasible mining project and to maximise the lasting development benefits to the region.

The FRHEP integrated storage facility (ISF) will be used to store the mine's waste rock and tailings and the hydroelectric facility will provide a renewable energy source to power the FRCGP for the life of the mine. There may be excess power from the FRHEP that will be made available for a power distributor to purchase and on sell to PNG users or export to Indonesia. The SPGP forms Stage 1 of this distribution grid which includes construction of the Northern Transmission Line to provide power to the FRCGP and other users along the infrastructure corridor and at the Vanimo Ocean Port.

The SIP provides the main access route to the mine, along with a regional airport at Green River and upgraded Vanimo port facilities. These facilities will be developed to service FRCGP activities as well as allowing for public and commercial use by other parties.

Together, the components of the Project form an opportunity to bring a major economic development project to the region that aligns with the Vision 2050 and the PNGDSP (see Section 2.4).

Through the course of the feasibility study work for the Project, it became apparent that there are multiple viable development pathways available. In settling on a scope of work, the study team endeavoured to balance a number of competing constraints that impact on the magnitude of the initial capital investment. These trade-offs will continue to be revisited in light of new information as the Project develops.

The feasibility study was based on high quality data collected over several decades by multiple owners and the input of experienced consultants, and included:

- Data from over 280 km of drilling supporting a high proportion of Measured and Indicated Mineral Resource for the HITEK deposits.
- Over 10 years of base line data which was available to support the design criteria selected for each of the design components.
- Input from numerous engineering consultants engaged to provide support in the development of key technical areas including: the logistics operation; mine plan; process plant design; ISF design; power supply; road, bridge and port design; and non-process infrastructure.
- A structured study approach which included a review of previous feasibility study components, selection of scope, engineering and development of cost estimates.

To shape the Project's scope, the following key development criteria were used:

- Target industry leading practice safety performance.
- Limit adverse impacts on the environment.
- Provide opportunities to improve the livelihoods of communities.
- Actively engage with key stakeholders to ensure long-term social licence to operate.
- Use an appropriate risk profile for investment.
- Subaqueous deposition of potentially acid forming (PAF) mine waste rock and tailings.
- Use existing infrastructure where possible.
- Align with the PNGDSP and policies.

A key design objective of the Project was to limit fugitive sediment emissions from the mine site and the potential for acid and metalliferous drainage (AMD) using the ISF as an engineered solution. Mine waste rock and process tailings will be stored subaqueously in the ISF which is designed to Australian National Committee on Large Dams (ANCOLD) standards. The design of the ISF has been subject to international expert peer review by PanAust's Tailings Independent Review Panel (TIRP), which assessed the adequacy of the ISF design and the underlying studies informing the design, and provided recommendations on whether additional studies or evaluations were required to address areas of uncertainty.

The ISF was designed as a large water dam rather than using conventional tailing storage facility design principles due to the higher level of stability and safety that forms the basis of the design for large water dams. This design philosophy was adopted by FRL to manage the risks associated with the characteristics of the ISF location, including seismic activity in the FRHEP area and the high rainfall, and the necessity for the ISF structure to remain stable under those conditions.

The selection of the infrastructure corridor route aimed to provide the FRCGP with a reliable access route to the site that maximised the use of existing infrastructure, limited the adverse environmental and social impacts of the Project and enhanced the broader social and third party commercial benefits of the Project.

## 5.1 Project Area

### 5.1.1 Defined Project Areas

Activities associated with the Project will occur in four geographically distinct areas:

- Mine area – includes the open-pit, process plant, mine access roads, site accommodation village and other ancillary infrastructure as shown in Figures 1.3 and 1.4. The mine area is characterised by very high rainfall, steep topography with few flat areas, intact biodiversity and sparse population.
- FRHEP area – incorporates the ISF, power generation facilities, Frieda River Port, FRHEP access road, and quarries to support construction of the FRHEP. The FRHEP area is a similar environment to the mine area, with very high rainfall, steep topography, intact biodiversity and sparse population.
- Infrastructure corridor – includes the access road from Vanimo to the mine site, concentrate pipeline, Green River Airport, transmission line and other ancillary infrastructure as shown in Figure 1.2. The transmission line that forms part of the SPGP is located within the infrastructure corridor and continues on west from Vanimo to the Indonesian border. The environment becomes increasingly influenced by human activity (primarily from forestry and agroforestry) with distance along the infrastructure corridor from the mine site towards the northern coast.
- 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 1.2). The port will be a mixed-use facility including two berths constructed to service outbound copper concentrate. An infrastructure area will be located in Vanimo for FRCGP support facilities.

### 5.1.2 Disturbance Area

Large-scale open-pit mines such as that planned for the FRCGP typically have a sizeable footprint centred around the mine itself. Together with the large body of water required for the FRHEP, and the land required for the SIP and SPGP, the Project footprint will cover approximately 16,000 ha (Table 5.1).

In order of land area, the largest components of the Project are the FRHEP reservoir (approximately 80% of the total footprint), SIP roads, the SPGP Northern Transmission Line, and the FRCGP open-pit and haul roads.

**Table 5.1 Indicative areas of disturbance associated with the Project**

Facility	Area (ha)
<b>Frieda River Copper-Gold Project</b>	
HITEK open-pit	520
Process plant and ore stockpile	35
Mine infrastructure area	15
Spoil dumps	235
Construction camp and site accommodation village	25
Haul roads and access roads (includes existing exploration access track)	220

**Table 5.1 Indicative areas of disturbance associated with the Project (cont'd)**

Facility	Area (ha)
<b>Frieda River Copper-Gold Project (cont'd)</b>	
Conveyor	55
Quarries	40
<b>Frieda River Hydroelectric Project</b>	
Reservoir	12,400
Embankment	35
Spillway	60
Frieda airstrip (predominantly existing disturbance)	20
FRHEP access road	80
Laydown areas	45
Spoil dumps	85
<b>Sepik Infrastructure Project</b>	
Green River Airport (existing disturbance)	20
Vanimo to Green River Road (existing disturbance)	225
Hotmin Road	225
Vanimo Ocean Port (includes existing land disturbance)	35
<b>Sepik Power Grid Project</b>	
Northern Transmission Line	1,770
<b>Total*</b>	<b>16,000</b>

\* Total disturbed area has removed areas where infrastructure footprints overlap. Therefore, area represents the total area of disturbance and is not equal to the addition of the project components.

## 5.2 Project Components Key Characteristics

### 5.2.1 Frieda River Copper-Gold Project

The FRCGP is based on development of the HITEK porphyry copper-gold orebodies. It comprises a large-scale open-pit mine feeding ore to a comminution and flotation process plant producing a copper-gold concentrate. A concentrate pipeline will transport the copper-gold concentrate to a concentrate dewatering, storage and export facility located at Vanimo. Figure 1.3 shows the general layout of the mine including the HITEK open-pit and supporting infrastructure.

Key characteristics of the FRCGP are shown in Table 5.2.

**Table 5.2 Key characteristics of the Frieda River Copper-Gold Project**

Item	Description
Mining method	Large-scale open-pit.
Mining	Approximately 1,500 Mt of mill feed and 1,450 Mt of waste rock to be mined from the open-pit over the life of the mine. Life of mine strip ratio of 1:1 (waste rock:ore).

**Table 5.2 Key characteristics of the Frieda River Copper-Gold Project (cont'd)**

Item	Description
Open-pit dimensions (ultimate pit)	<p>The Horse-Ivaal-Trukai (HIT) open-pit will be 2.6-km-long and 2.4-km-wide, the Ekwai open-pit will be 0.8-km-long and 0.6-km-wide and the Koki open-pit will be 0.7-km-long and 0.9-km-wide. The Ekwai open-pit void will be used as an intermediate ore stockpile and contact water sump.</p> <p>The combined HITEK open-pit (comprised of the HIT, Ekwai and Koki open-pits) is referred to in singular form throughout this EIS.</p>
Mine life	Approximately 33 years (with an additional 7-year implementation period).
Mining rate	<p>Average mining rate of 45 Mt/year of mill feed and 42 Mt/year of waste rock, and peak total material movements of 135 Mt/year.</p> <p>The total material mined over the life of mine will be 2,950 Mt comprising 1,500 Mt of mill feed (0.45% copper and 0.24 g/t gold) and 1,450 Mt of waste rock.</p>
Processing method	Primary crushing, grinding and flotation circuit. Initially 1 x 28 MW SAG and 2 x 22 MW ball mills expanding to 2 x 28 MW SAG and 4 x 22 MW ball mills in Year 8.
Mill throughput	<p>Nominal volumetric ore processing rates are:</p> <ul style="list-style-type: none"> <li>• Years 1 to 7: up to 49 Mt/year (6,000 t/h).</li> <li>• Year 8 to LOM: up to 65 Mt/year (8,000 t/h).</li> </ul>
Concentrate and metal production	<p>Concentrate and metal production will include:</p> <ul style="list-style-type: none"> <li>• Average copper-gold concentrate production of 735,000 wet metric tonnes (wmt) per year with a peak of 1.1 Mwmt per year at 9.5% moisture.</li> <li>• Average copper production 175,000 t per year (peak of 290,000 t per year).</li> <li>• Average gold production 230,000 ounces (oz) per year (peak of 370,000 oz per year).</li> </ul>
Tailings and waste rock storage	<p>A spoil dump will be developed in the headwaters of the Ok Binai. This spoil dump will store non-acid forming (NAF) waste rock from Year -1 and organic pre-strip material over the 33-year mine life.</p> <p>All waste rock (other than that reporting to the Ok Binai waste dump) including PAF waste rock will be placed within the ISF by barge. At the barge loading station the waste rock will be stockpiled, reclaimed and loaded into 5,000 t barges. The barges will transport and deposit the waste rock for subaqueous storage in the ISF.</p> <p>Thickened tailings will be pumped via a dedicated pipeline from the process plant for subaqueous storage in the ISF.</p>
Power requirement and distribution	<p>Power demand for the mine:</p> <ul style="list-style-type: none"> <li>• Approximately 180 MW (1,400 gigawatt hours per year (GWh/year)) energy demand increasing to 280 MW (2,200 GWh/year) in Year 8.</li> </ul> <p>Power demand offsite:</p> <ul style="list-style-type: none"> <li>• Vanimo Ocean Port concentrate export facility and Vanimo Infrastructure Area – 4 MW (23 GWh/year).</li> <li>• Two concentrate booster pump stations – 7 MW (42 GWh/year).</li> </ul> <p>Power supply to the process plant will be provided by a 22-km-long, 132 kV transmission line from the hydroelectric power facility.</p> <p>Power supply to the offsite facilities will be provided by the Northern Transmission Line as part of the SPGP.</p>

**Table 5.2 Key characteristics of the Frieda River Copper-Gold Project (cont'd)**

Item	Description
Raw water requirement and supply	Raw water will be sourced from the ISF at a rate of approximately 3,800 cubic metres per hour (m <sup>3</sup> /h) for ore processing and general non-potable consumption.  Potable water will be sourced by treating water from the Nena River upstream of the ISF and pumped to the site accommodation village.
Mine infrastructure area	The mine infrastructure area (MIA) will be located close to the HITEK open-pit. The MIA will consist of the following major facilities: <ul style="list-style-type: none"> <li>• Workshops.</li> <li>• Warehouse.</li> <li>• Muster, training and dining areas.</li> <li>• Bulk fuel storage.</li> </ul>
Overland logistics	Overland logistics includes: <ul style="list-style-type: none"> <li>• 39 km mine access road from Hotmin to the mine (unsealed 7.5-m-wide dual-lane).</li> <li>• 33 km unsealed 7.5-m-wide dual-lane Link Road from the hydroelectric power facility to the mine.</li> <li>• A buried 325-km-long pipeline providing transport of concentrate to the Vanimo Ocean Port.</li> <li>• Equipment and goods will be transported via road along the main access route during operations.</li> <li>• Coaches will be used to transport personnel between points of hire along the public road and from the Green River Airport to the mine.</li> </ul>
Ocean/riverine logistics	During construction, freight will be imported via existing ports at Wewak, Lae and Madang and barged upstream along the Sepik River to the Frieda or May river ports until upgrade of both the Vanimo Ocean Port and the Vanimo to Green River Road has been completed. Freight will then be trucked from Vanimo to Green River and barged from the Upper Sepik River Port downstream along the Sepik River. Once the main access route from Green River to the mine is complete all freight will be trucked to site.  During operations, freight will be imported via the upgraded Vanimo Ocean Port and trucked to site.  Bulk ocean carriers for concentrate export, multipurpose feeder vessels for containerised cargoes and parcel tankers for diesel will be utilised.  Riverine transport will be used during operations on an as required basis.
Employment (staff and on-site contractors)	<b>Construction:</b> Peak construction workforce of approximately 2,750 personnel. <b>Operations:</b> Average of approximately 2,080 personnel.
Accommodation	<b>Construction:</b> The main construction camp will be located in the Nena River valley approximately 5 km from the process plant and will accommodate up to 3,500 personnel. <b>Operations:</b> A site accommodation village at the mine site will house approximately 2,780 personnel with a further 100 personnel to be accommodated at Vanimo for office, logistics and port operations.

### 5.2.2 Frieda River Hydroelectric Project

The FRHEP comprises a 600 MW hydroelectric power facility located in the Frieda, Nena, and Niar river valleys. This facility will generate power for the FRCGP and the ISF will provide subaqueous storage of waste rock and tailings.

Key characteristics of the FRHEP are shown in Table 5.3.

**Table 5.3 Key characteristics of the Frieda River Hydroelectric Project**

Item	Description
Power generation	<p>Hydroelectric power generation will be produced using Francis turbines with an installed hydroelectric power capacity of up to approximately 600 MW and an annual maximum energy generation of 2,800 GWh/year (up to 490 MW). At least one turbine at a time will be offline for periods of planned maintenance and one will be on standby.</p> <p>From approximately Year 2, the excess power available for export will be in the order of 1,450 GWh/year (270 MW); this will reduce to 760 GWh/year (150 MW) from Year 8 due to the increase in power demand for the FRCGP.</p> <p>The powerhouse will be approximately 190 m x 34 m in size and will be located at the toe of the embankment. The powerhouse complex will include:</p> <ul style="list-style-type: none"> <li>• Tunnel exit portal and penstocks.</li> <li>• Main turbine hall housing the generating equipment.</li> <li>• Erection bay and workshop area for assembling the power generation equipment and undertaking maintenance.</li> <li>• Local control room and office facilities.</li> <li>• Electrical equipment rooms.</li> <li>• Step-up transformers and adjacent substation building.</li> <li>• A tailrace discharging to the Frieda River.</li> <li>• A penstock pipeline to connect the tunnel to the powerhouse.</li> </ul>
Design	<p>The FRHEP will include an engineered ISF for the storage of construction spoil, mine waste rock and tailings, and sediment control.</p> <p>The embankment will be located in the Frieda River Valley and has been designed as an engineered rock-fill embankment with a central asphalt core. Design characteristics include:</p> <ul style="list-style-type: none"> <li>• Embankment height of 190 m (at RL 238 m) using 30 million cubic meters (Mm<sup>3</sup>) of fill material.</li> <li>• Crest elevation of RL 238 m and maximum operating water level of RL 226 m.</li> <li>• Total storage capacity of 9.6 billion cubic metres (Bm<sup>3</sup>).</li> <li>• Maximum waste rock and tailings storage capacity of 3.3 Bm<sup>3</sup> (approximately 4.6 billion tonnes (Bt)).</li> <li>• Designed to store and release water from a Probable Maximum Flood event (30,000 m<sup>3</sup>/s).</li> <li>• Designed to withstand maximum credible earthquake peak ground acceleration of 1.09 g.</li> <li>• Catchment area of 1,033 km<sup>2</sup>.</li> <li>• Operating life of greater than 100 years.</li> </ul>
Construction facilities	<p>The FRHEP will require the development of the following site-based facilities to allow construction of the embankment, spillway and powerhouse:</p> <ul style="list-style-type: none"> <li>• Quarry.</li> <li>• Cofferdams.</li> <li>• Diversion tunnels.</li> <li>• Concrete batch plant.</li> <li>• Maintenance workshop.</li> <li>• Geotechnical laboratory.</li> </ul> <p>The FRHEP will be constructed in a single stage over a 5-year construction duration.</p>
Overland logistics	<p>40 km unsealed 7.5-m-wide dual-lane FRHEP access road from the Frieda River Port to the powerhouse.</p>

**Table 5.3 Key characteristics of the Frieda River Hydroelectric Project (cont'd)**

Item	Description
Ocean/riverine logistics	The Sepik and Frieda rivers will support transport of construction materials for the FRHEP. The rivers will also provide a contingency in the event of loss of access along the infrastructure corridor.
Employment (staff and on-site contractors)	<b>Construction:</b> Peak construction workforce of up to approximately 2,260 personnel. <b>Operations:</b> Approximately 130 personnel.
Accommodation	<b>Construction:</b> The FRHEP construction camp near the powerhouse will house up to 3,300 personnel. <b>Operations:</b> An accommodation village near the powerhouse will house up to 420 personnel, which includes sufficient beds for shutdown periods.

### 5.2.3 Sepik Infrastructure Project

The SIP will provide a range of regional infrastructure that will serve both the mine and other users. This includes a 286-km-long public access road from Vanimo to Hotmin, a regional airport at Green River and the Vanimo Ocean Port.

Key characteristics of the SIP are shown in Table 5.4.

**Table 5.4 Key characteristics of the Sepik Infrastructure Project**

Item	Description
Vanimo to Green River Road and Hotmin Road	The existing road from Vanimo to Green River will be upgraded (Vanimo to Green River Road) and a new public road constructed from Green River to Hotmin (Hotmin Road). The road will be 7.5-m-wide with a gravel pavement surface, built to allow for 12 tonne axle loading. Some road sections may be sealed during the operations phase. The public road will allow for public transport, commercial ventures and access to new markets.
Sepik River bridge	A new bridge will be built on the Hotmin Road at the Sepik River, consisting of: <ul style="list-style-type: none"> <li>• Steel box girder superstructure.</li> <li>• Dual-lane deck with 8 m width between kerbs.</li> <li>• Total bridge length of 350 m.</li> </ul> A cross-river ferry service will be required during construction of the bridge.
Green River Airport	<ul style="list-style-type: none"> <li>• The existing airstrip at Green River, located 150 km from the mine area, will be upgraded for commercial use.</li> <li>• The airstrip will be made suitable for up to Lockheed C-130 sized aircraft.</li> <li>• The new facilities will include a terminal with the capacity for 80 passengers, baggage handling facilities, immigration and customs, freight handling and storage facilities.</li> </ul>
Vanimo Ocean Port	Construction of two new berths at the Vanimo Ocean Port to provide import and export facilities for the Project and other users.
Employment (staff and on-site contractors)	<b>Construction:</b> Peak construction workforce of approximately 880 personnel. <b>Operations:</b> Approximately 250 personnel.

### 5.2.4 Sepik Power Grid Project

The SPGP consists of a new transmission line from the FRHEP to the Indonesian border via Vanimo. The Northern Transmission Line will provide power to the FRCGP facilities along the

infrastructure corridor and at the Vanimo Ocean Port, with excess power made available for export and for other regional users.

Table 5.5 provides a summary of the SPGP components and their characteristics.

**Table 5.5 Key characteristics of the Sepik Power Grid Project**

Item	Description
Northern Transmission Line	<p>A 370-km-long 275 kV transmission line from the FRHEP to the Indonesian border via Vanimo.</p> <p>The Northern Transmission Line will provide power to the FRCGP facilities based at Green River and Vanimo.</p> <p>Excess power may be made available for a power distributor to sell to regional users within PNG and for export to Indonesia.</p> <p>The Northern Transmission Line will be located within the infrastructure corridor and will follow the existing Vanimo-Jayapura Highway from Vanimo to the Indonesian border.</p>
Substation	<p>Three substations will be located along the Northern Transmission Line at the FRCGP site accommodation village, near Green River and at Vanimo.</p>
Rural electrification	<p>A 19.1 kV single wire earth return (SWER) will be installed along the Northern Transmission Line to allow a power distributor to sell excess power to communities along the infrastructure corridor.</p>
Employment (staff and on-site contractors)	<p><b>Construction:</b> Peak construction workforce of approximately 290 personnel.</p> <p><b>Operations:</b> Approximately 50 personnel.</p>

### 5.3 Resettlement

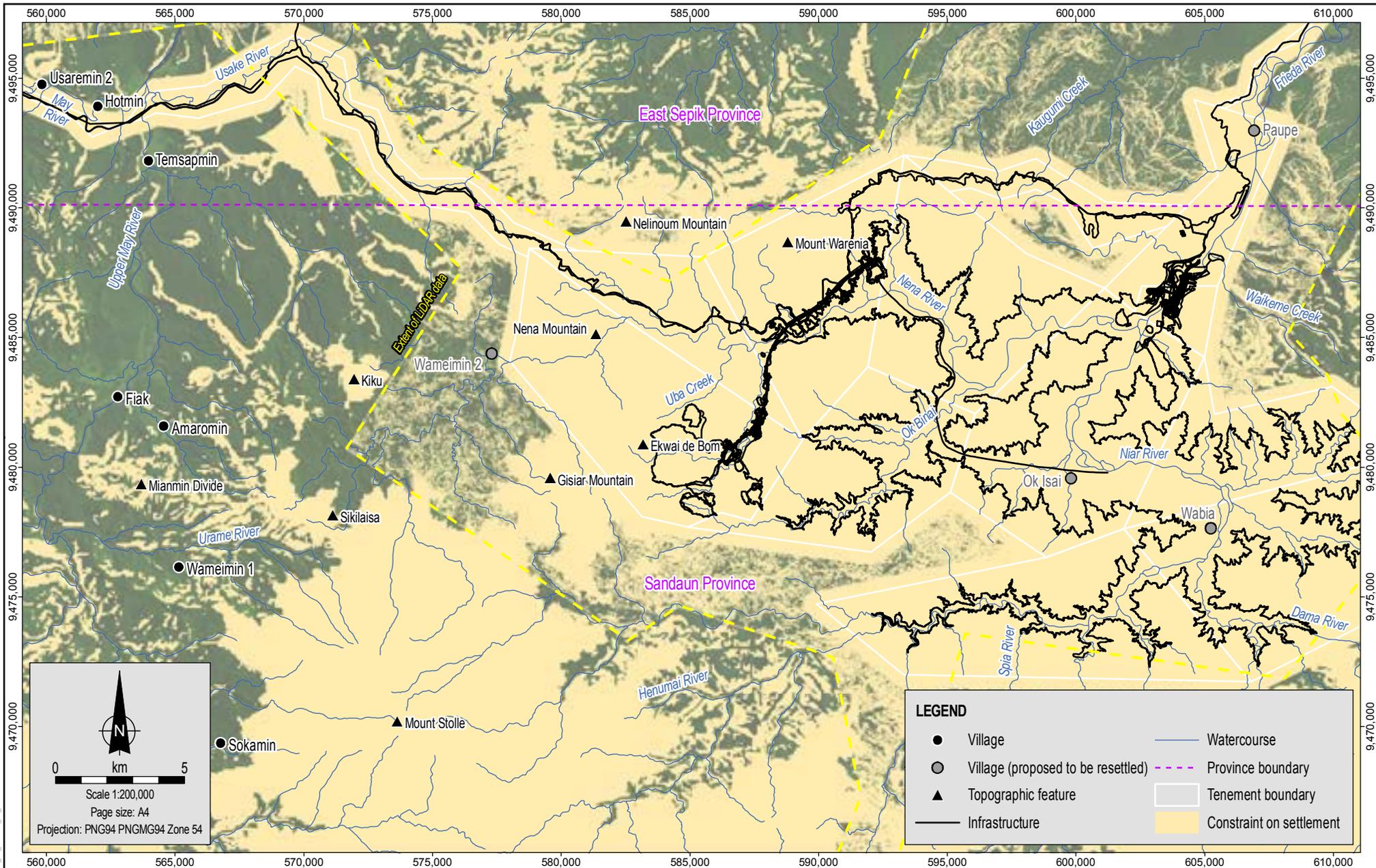
Construction and eventual flooding of the ISF reservoir in a portion of the Frieda River catchment (including the Nena, Ok Binai, Niar and Anai rivers) for the FRHEP will displace the villages of Ok Isai and Wabia.

The village of Paupe is located north of the Frieda River airstrip adjacent to the Frieda River and 5 km downstream of the proposed hydroelectric power facility. During the seven-year implementation phase of the Project, potential amenity impacts to Paupe village are anticipated due to proximity to Project infrastructure.

The proximity of Wameimin 2 to the SML and mine access road will likely result in high levels of in-migration to the village, before and during development of the mine, as well as safety risks to people due to potential interaction with heavy vehicles along the mine access road. Wameimin 2 is also located approximately 3 km from the Nena deposit and would need to be resettled if this deposit were to be developed in the future.

As a result, the residents of the Ok Isai, Wabia, Paupe, and Wameimin 2 villages will be resettled. Options for resettlement sites have been identified through consultation with residents of these villages; however, final locations are yet to be agreed. Figure 5.1 shows the areas where physical constraints may restrict settlement, such as the tenement locations, very steep slopes, elevation and distance from a water supply. Options for resettlement locations are being investigated outside of these constraints areas.

Resettled villages will be provided with housing and associated facilities to a standard greater than current facilities.



MOI Reference: 11575E\_11\_GS037\_00\_5

Source:  
 Resettlement constraints compiled by Coffey.  
 Infrastructure, roads and tenements from FRL.  
 Villages, topographic features from FRL and Coffey.  
 Rivers from NSO. Provinces from NMB.  
 Landsat satellite imagery from FRL (capture date unknown).



Date: 10.09.2018  
 Project: 754-ENAUABTF11575A  
 File Name: 11575\_11\_F05.01\_GIS

**Frieda River Limited**  
 Sepik Development Project



**Constraints on settlement**

Figure No:  
**5.1**

## 5.4 Development Schedule

Figure 5.2 shows the indicative development schedule for the Project. Feasibility study engineering and Project design have progressed simultaneously with the environmental and social studies and preparation of this EIS. Results from the EIS studies have informed elements of the Project's design and the development proposal will continue to evolve as engineering work proceeds through the detailed design phase.

The schedule is based on obtaining Special Mining Lease (SML) approval together with a decision to proceed with the Project from the Frieda River Joint Venture, which will consider several commercial factors including copper and other commodity prices, and completion of satisfactory financing arrangements.

Key milestones in the Project are:

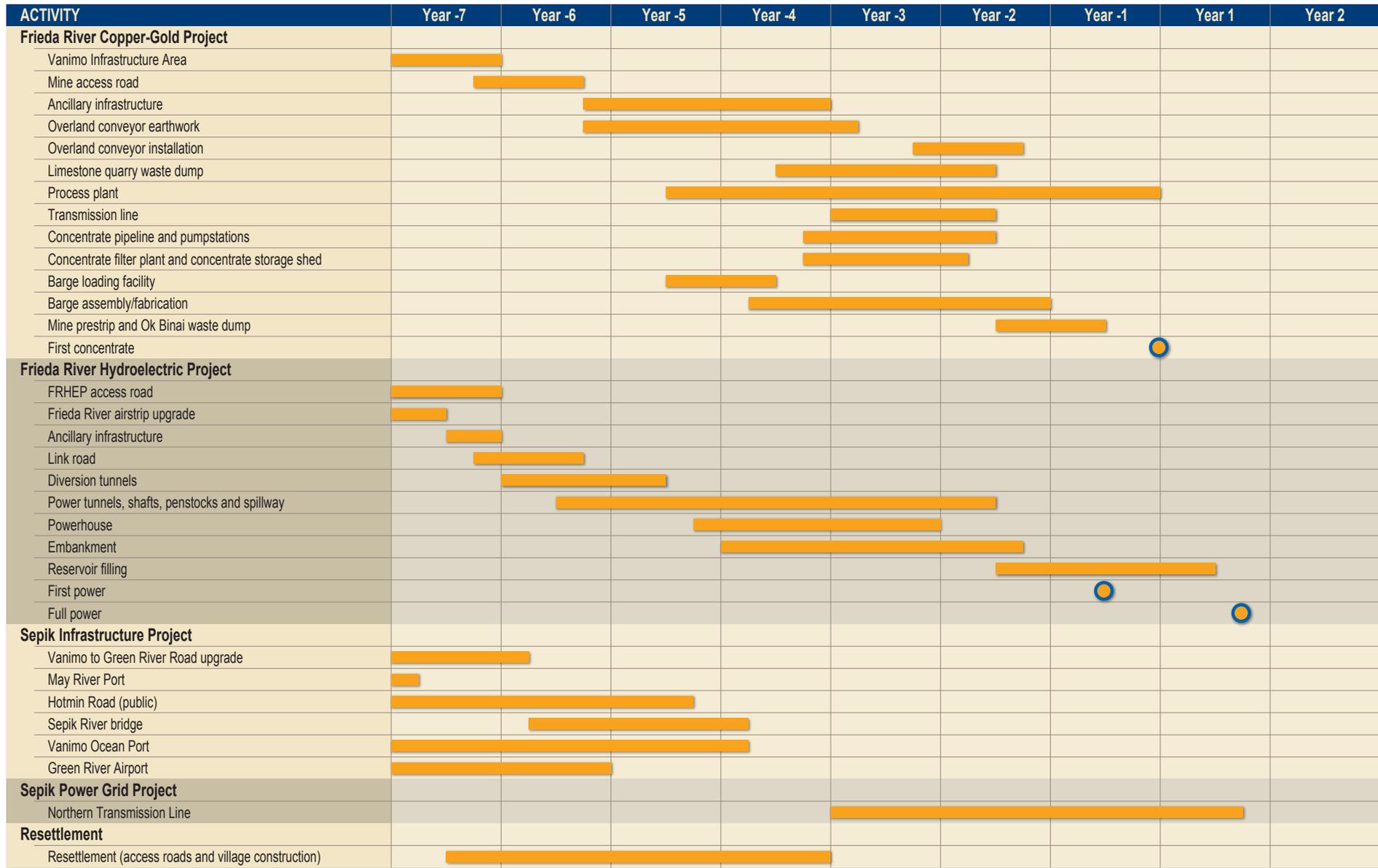
- Submission of the final EIR and NOI to CEPA on 20 December 2017.
- Completion of the 2018 Feasibility Study in Q4 2018.
- Registration of the revised SML and associated tenement applications.
- Submission of the EIS and environment permit application and acceptance by CEPA in Q4 2018.
- Receipt of EIS approval in principle.
- Receipt of environment permit.
- Grant of SML and other associated tenements.
- Commencement of critical detailed design in Year -8.
- Final Investment Decision for the Project in Year -7.
- Commencement of preconstruction enabling works in Year -7.
- Commencement of construction at end of Year -7.
- Commissioning and commencement of mining in Year -1.
- Production and export of first concentrate in Year 1.

## 5.5 Frieda River Copper-Gold Project

### 5.5.1 Mineral Resource

The FRCGP represents one of the largest undeveloped copper-gold deposits in the world. Exploration and drilling programs at the HITEK porphyry copper-gold deposits have been undertaken by FRL and its predecessors since the 1960s and have allowed the deposits to be classified as shown in Table 5.6, which is reported in accordance with the Joint Ore Reserves Committee Code (JORC Code, 2012).

The HITEK porphyry copper-gold deposits contain an estimated combined Measured, Indicated and Inferred Mineral Resource of 2,640 Mt at grades of 0.44% copper and 0.23 g/t gold (PanAust, 2017; Table 5.6). The deposits contain 815 drill holes of which 537 (162,500 m) are sufficiently verified by best practice quality assurance and quality control measures on key data inputs, including copper and gold assay grades, to be used for Mineral Resource estimation.



Date: 14.09.2018  
 Project: 754-ENAUABTF11575B  
 File Name: 11575\_11\_F05.02\_GRA

Frieda River Limited  
 Sepik Development Project



Sepik Development Project  
 indicative development schedule

Figure No: 5.2

**Table 5.6 Measured, Indicated and Inferred Mineral Resource estimate**

Class	Mineral Resource (Mt)	Copper Grade (%)	Gold Grade (g/t)	Silver Grade (g/t)
Measured	620	0.53	0.30	0.82
Indicated	1,240	0.44	0.22	0.75
Measured and Indicated Mineral Resource	1,860	0.47	0.25	0.77
Inferred	780	0.35	0.18	0.83
<b>Total</b>	<b>2,640</b>	<b>0.44</b>	<b>0.23</b>	<b>0.79</b>

\*At 0.2% cut-off grade (total copper).

## 5.5.2 Mining

The open-pit mine will be a large-scale truck and shovel operation. The mountainous terrain and high rainfall conditions require more than one equipment fleet size to effectively manage the material movement through mine development. Equipment fleet size will be staged to enable access into steep, narrow topographical areas and manage the removal of vegetation, topsoil and overburden material.

The total material mined over the 33-year life of mine will be 2,950 Mt, comprising 1,500 Mt of mill feed (0.45% copper and 0.24 g/t gold) and 1,450 Mt of waste rock. There will be an average processing of 45 Mt/year of mill feed and 42 Mt/year of waste, with peak total material movements of up to 135 Mt/year.

The HIT open-pit will be up to 2.6-km-long and 2.4-km-wide, the Ekwai open-pit will be up to 0.8-km-long and 0.6-km-wide and the Koki open-pit will be up to 0.7-km-long and 0.9-km-wide. The Ekwai open-pit void will be used as an intermediate ore stockpile.

The HITEK open-pit designs are based on Measured and Indicated Mineral Resources and excludes Inferred Mineral Resources. This supports the proved and probable HITEK Ore Reserve (Table 5.7).

**Table 5.7 HITEK 2018 Ore Reserve**

Class	Ore Reserve (Mt)	Copper grade (%)	Gold grade (g/t)
Proved	604	0.51	0.30
Probable	761	0.42	0.21
<b>Total</b>	<b>1,365</b>	<b>0.46</b>	<b>0.25</b>

Source: FRL, 2018

Ore and waste will be mined from the open-pit 24 hours per day, 365 days per year. Annual estimates of mill feed including Inferred Resources within the open-pit design and waste rock production over the mine life are shown in Table 5.8 including classification of waste rock by total sulphur content as a measure of its acid-forming potential. Figure 5.3 shows open-pit staging for years 4, 7, 17, and end of mine.

**Table 5.8 Mill feed and waste rock mining schedule**

Project year	Mill feed (Mt)	Waste rock (Mt)	Proportion of PAF material in waste rock (%)*	Total material mined (Mt)†
-1	0	6	47	6
1	36	23	42	59
2	40	28	60	69
3	45	40	59	85
4	38	44	70	81
5	49	33	49	85
6	41	39	52	85
7	40	45	61	89
8	62	65	74	121
9	65	65	82	135
10	65	65	94	124
11	65	60	87	120
12	56	65	90	127
13	46	65	97	114
14	56	65	91	123
15	61	65	91	121
16	44	65	96	114
17	45	65	99	106
18	46	65	96	113
19	50	64	95	114
20	41	56	92	99
21	40	58	95	98
22	47	65	91	112
23	50	50	95	95
24	38	59	96	95
25	38	63	96	95
26	27	23	100	50
27	40	10	100	50
28	40	3	99	50
29	38	3	100	45
30	37	3	100	41
31	37	2	100	39
32	37	0.1	100	37
33	35	0.5	100	23
<b>Total</b>	<b>1,492</b>	<b>1,429</b>	-	<b>2,921</b>

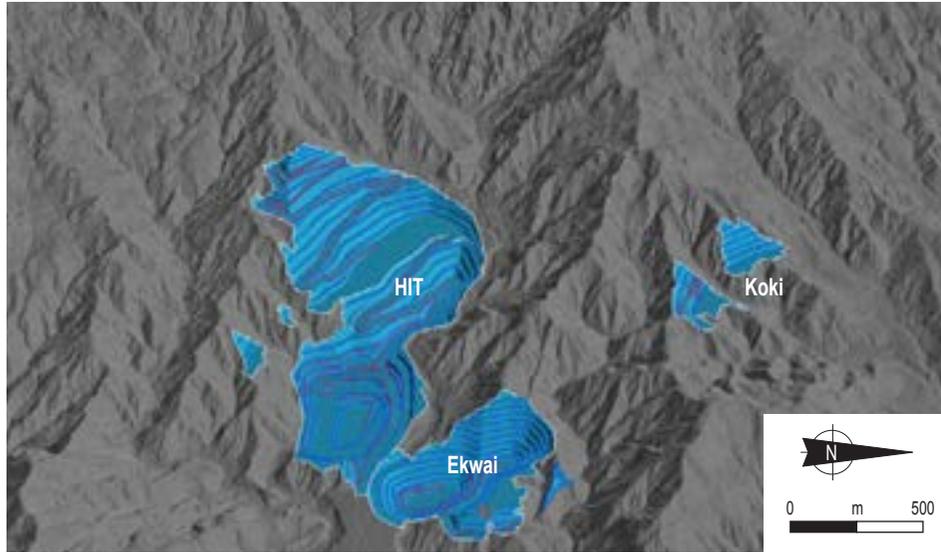
\* Includes waste classified as amber, red and high red categories (see Section 5.5.3).

† Mill feed and waste rock values may not add to the total mined material due to stockpiling of ore.

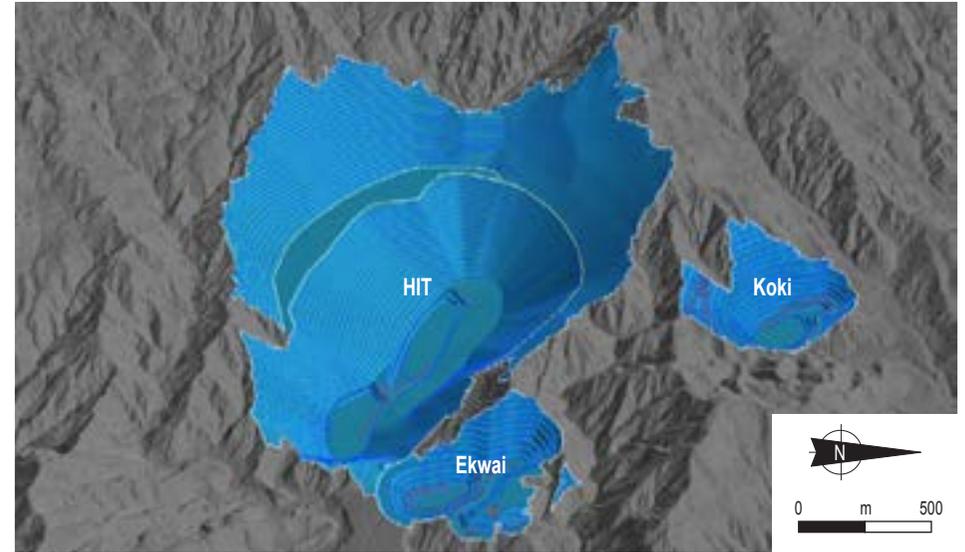
The general sequence of mining activities will include:

- Mine pioneering: Clearing of vegetation and grubbing and removal of topsoil.

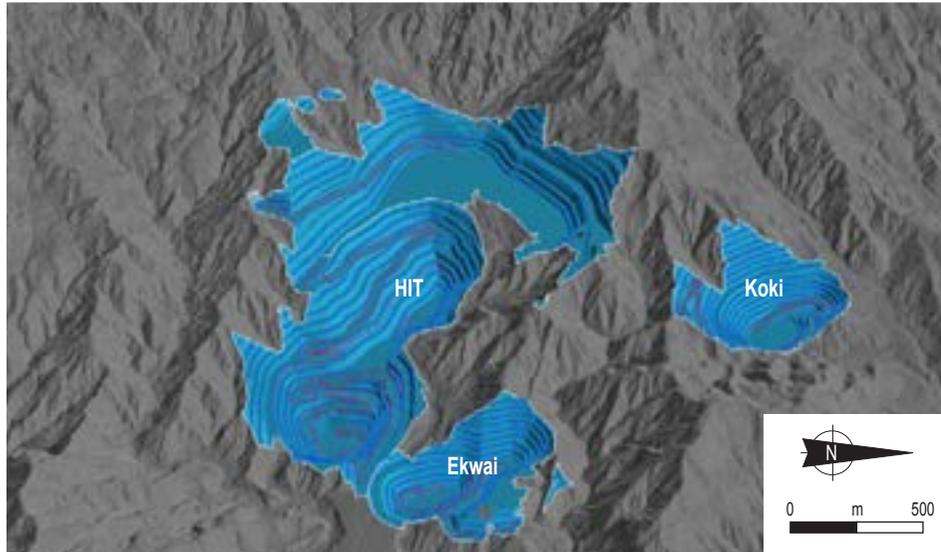
HITEK mine development status end of Year 4



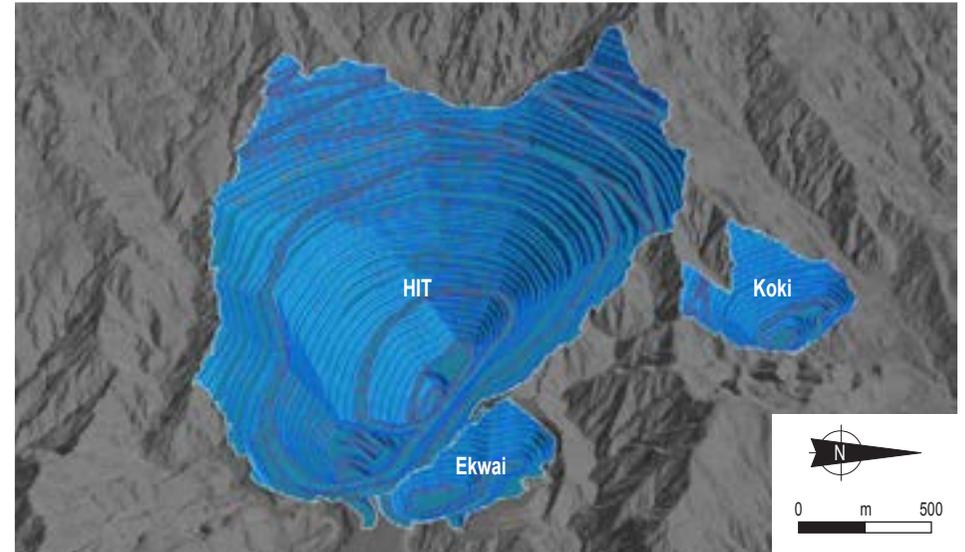
HITEK mine development status end of Year 17



HITEK mine development status end of Year 7



HITEK mine development status end of mine life



AI Reference: 11575\_11\_GRA047.a\_2



Date: 16.08.2018  
 Project: 754-ENAUABTF11575B  
 File Name: 11575\_11\_F05.03\_GRA

Frieda River Limited

Sepik Development Project



Open-pit staging

Figure No: 5.3

- Bulk pre-stripping and bench preparation.
- Drilling and blasting.
- Excavating, hauling, crushing and conveying of ore to the process plant for processing.
- Excavating, trucking, crushing, conveying and barging of waste rock for deposition within the ISF.
- Rehabilitation and mine closure, including flooding of the open-pit, at the completion of mining.

Stockpiling of run-of-mine (ROM) material will be required to optimise the value of the mill feed sent to the process plant.

This sequence is described below, except for rehabilitation and mine closure which is described in Section 5.5.10, Decommissioning and Rehabilitation.

Prior to the commencement of open-pit development, areas in and immediately adjacent to the open-pit and MIA will be cleared of vegetation and prepared for mining. This process will be completed in stages in accordance with the mine plan and will include:

- Establishing stormwater and sediment control structures to reduce transport of coarse sediment to the downriver environment.
- Clearing vegetation and topsoil.
- Bulk pre-stripping of spoil below the topsoil layer.

Equipment required for pioneering and pre-stripping work includes excavators, articulated dump trucks, rear dump trucks and dozers.

In general, clearing will occur as close to the time of mining as possible to limit the potential for erosion. Other general measures to be implemented to control the extent of erosion include:

- Limiting the extent of vegetation clearance as much as is operationally practicable.
- Moving material to designated spoil dumps.
- Progressively rehabilitating disturbed areas, where practical.

### **Drilling and Blasting**

Less than 10% of material can be excavated without drilling and blasting (known as 'free dig'). Drilling and blasting will therefore be required for the majority of material to be mined and will be largely dependent on the rock hardness and competency of the material. Drilling and blasting operations will be carried out using a combination of emulsion-based explosives suitable for wet and potentially reactive ground where required.

The estimated maximum instantaneous charge for blasting is 1,500 kilograms (kg), based on three holes initiating concurrently at 500 kg/hole. On average, up to five blasts per week will be required over the life of the mine, with this increasing to two blasts per day at times. Ammonium nitrate fuel oil (ANFO) will be used at an average rate of approximately 18,000 t/yr. Blasting will occur during daylight hours and will be prepared in consultation with drill and blast engineers to ensure the safety of mine employees and adequate fragmentation of the rock.

## Excavating and Hauling

Rock will be mined using a fleet of hydraulic shovels, excavators, front-end loaders and haul trucks (Plate 5.1), with a supporting fleet of bulldozers, graders and drill rigs. Table 5.9 lists the mine equipment to achieve the required schedule.

**Table 5.9 Indicative mine equipment fleet**

Equipment Item	Initial fleet size	Maximum fleet size
<b>Drills</b>		
Large-blasthole drill rig	2	6
Down-the-hole drill rig (pre-split drilling)	2	2
Depressurisation drill	1	3
<b>Blasting</b>		
Stemming truck (blasthole stemming)	1	2
<b>Loading units</b>		
36-cubic metre (m <sup>3</sup> ) face shovel (electric)	2	4
36-m <sup>3</sup> excavator	1	2
14-m <sup>3</sup> excavator	1	1
<b>Dozing units</b>		
Large tracked dozer – Primary fleet	3	8
Medium tracked dozer – Tertiary fleet	2	7
Large wheel dozer (or equivalent) – General	2	2
<b>Haul trucks</b>		
220 t capacity, rear-dump haul truck – Primary	12	53
90 t capacity haul dump truck – Tertiary	7	7
40 t capacity articulated dump truck – Pioneering	15	24
<b>Road construction and maintenance</b>		
Large grader	2	3
Medium grader	1	2
Medium excavator	1	1
Articulated haul truck	1	1
Roller compactor	2	3
Vibratory soil compactor	2	2
<b>Miscellaneous – Mining equipment</b>		
Lube truck	2	3
Tyre handler	1	1
Service truck	2	3
Crane	3	3
Forklift	1	2
Bobcat	1	1
Water trucks	2	3
<b>Quarry and Earthworks</b>		
100 to 150-mm drill rig	3	3
Small-medium excavator	5	7
Small-medium front-end loader	1	2
Various crushing and screening equipment	4	8

Mining will progress through a sequence of benches, berms and haul roads constructed in the open-pit in accordance with the parameters shown in Table 5.10. The proposed open-pit designs will result in the ultimate HITEK open-pit being split into eleven mining stages; seven for HIT and two each for Ekwai and Koki. The design stages and open-pit sequencing maximise value while delaying diversion of the major creeks within the planned mining area for as long as possible and therefore reducing water management requirements. Figure 5.3 shows the open-pit staging for development.

**Table 5.10 Average nominal open-pit design parameters\***

Parameter	Value
Bench height (m)	15 m.
Bench width (m)	Between 30 m to >500 m.
Berm width (m)	Depends on the inter-ramp slope angle, bench height and bench face angle. Typically varies between 10 to 20 m.
Ramp width (m)	43 m based on a typical 220 t truck.
Inter-ramp slope height	Maximum of 180 m.
Batter angle (degrees)	Typically varies between 55° to 75°.
Overall angle (degrees)	Typically varies between 30° to 50°.

\* Parameters will be subject to ongoing review through subsequent phases of mine design.

Rock will be loaded into and hauled by a number of 90 t capacity trucks initially and 220 t capacity trucks to a ROM pad and feed primary crushers adjacent to the open-pit. A dedicated overland conveyor system approximately 9-km-long will be used to transport ore from the primary crushing facility to the process plant, and waste rock from the waste rock crushing facility to the barge loading facility. The conveyors will be fitted with belt scales to measure throughput and metal detectors to detect and remove metal elements from ore and waste.

The MIA will be located close to the HITEK open-pit to support mining activities. The MIA will include the following facilities:

- Mobile and fixed plant workshop.
- Tyre workshop.
- Warehouse.
- Muster, training and dining areas.
- Bulk fuel storage.
- Vehicle wash bays.

### 5.5.3 Waste Rock Management

Waste rock is defined as material with subeconomic mineral concentration that must be excavated to gain access to the ore. The primary factor that determines the requirements for management of waste rock is its potential to produce acid upon exposure to oxygen, and its consequent generation of drainage that is both acidic and contains elevated concentrations of dissolved metals. The composition and variability of the waste material from the HITEK deposits was therefore evaluated in terms of its geochemistry, with a focus on acid-forming potential. The results of this evaluation have guided the proposed management strategy for the short and long-term management of waste rock.

#### Waste Rock Characteristics

Four geochemical characterisation programs have been undertaken on waste rock samples by the geochemistry specialist companies Environmental Geochemistry International (EGi) and SRK

Consulting (SRK). The first geochemical characterisation program was completed in 1996 by EGi, and each subsequent geochemical characterisation program has refined and built on the body of knowledge regarding the geochemical characterisation of the waste rock and options for its management. The most recent geochemical characterisation program was completed in 2016 by EGi and the results of this and other geochemical characterisation programs are reported in Appendix 1.

A total of 461 samples from the HIT deposit, 26 samples from the Ekwai deposit and 54 samples from the Koki deposit were assessed to determine their acid-forming potential.

The geochemical characterisation programs indicated that waste rock contains little acid neutralising capacity (ANC), with acid generating capacity mainly a function of sulphur content and alteration. Management of the potential for AMD is a key focus for the Project. Classification of the waste rock lithologies expected to be encountered during mining in terms of their acid-forming potential is described in Appendix 1.

Testwork reported in Appendix 1 established that the majority of waste rock exposed during mining will have high to very high sulphur (S) content (averaging 4% S) and low to zero ANC and has the potential to generate AMD. Given the limited ANC available, and in the absence of any mitigation, it is likely that strong acid conditions would develop within weeks to a few months of exposure after the material is blasted and excavated during the mining process. Waste rock that does have some ANC may take in the order of months to a year to acidify, but the evidence to date suggests that it is unlikely there will be significant tonnages of waste rock with a high ANC that would provide a prolonged lag period of many years during which circum-neutral drainage would be produced. About 22% of HIT samples tested were classified as NAF. A higher percentage of samples tested were classified as NAF for Ekwai (31%) and Koki (33%).

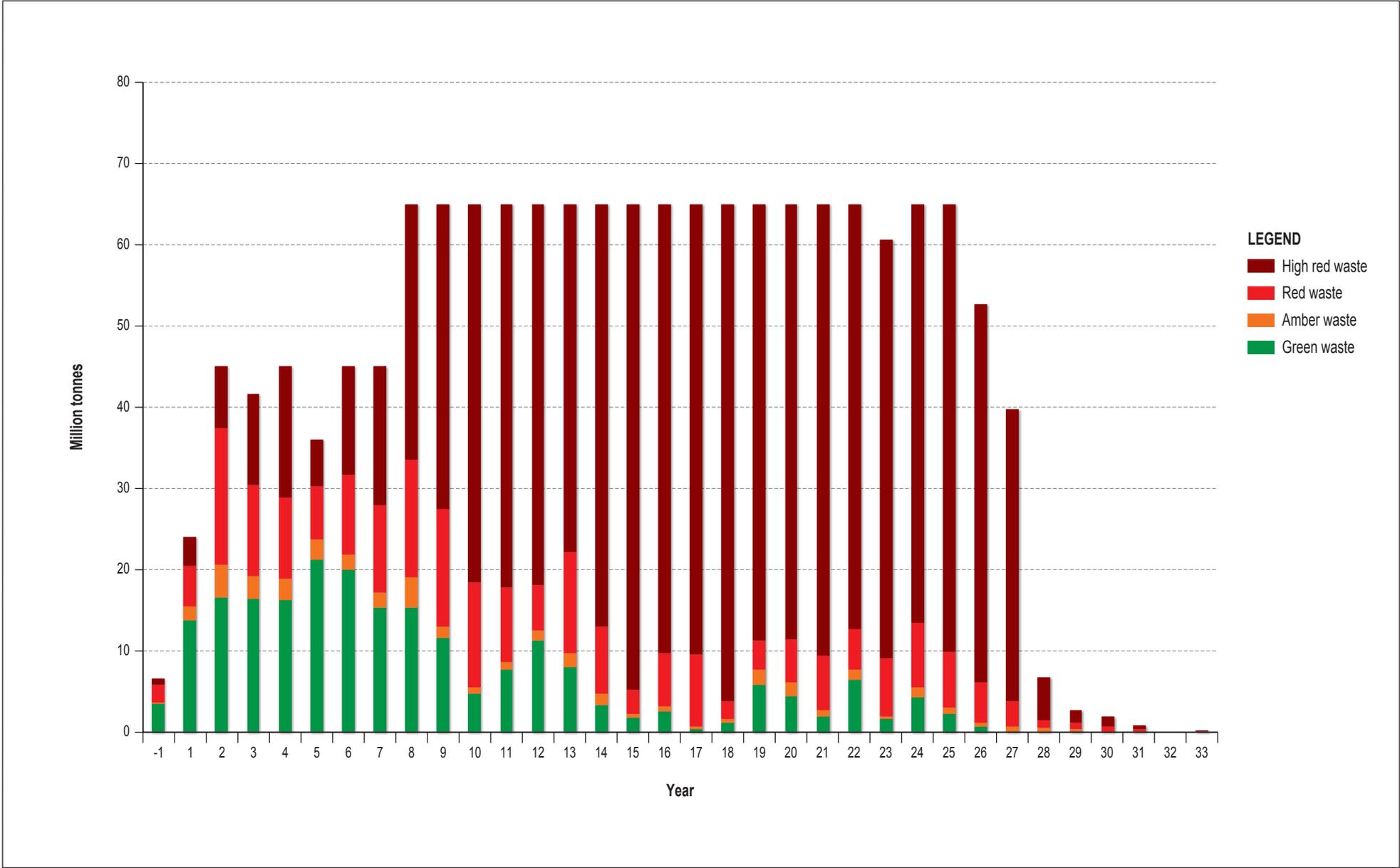
When informed by a comprehensive geochemical characterisation program such as that completed for the Project, the percentage of total sulphur in waste rock can be used for mine planning, as well as during operations, to allow rapid identification of NAF and PAF material and therefore its appropriate handling and management. The following criteria was adopted for the modelling of pit shell exposures and for waste rock management planning purposes:

- Green (NAF): <0.5% S or totally oxidised.
- Amber (PAF): 0.5 to 1.0% S.
- Red (low sulphur) (PAF): 1.0 to 3.0% S.
- Red (high sulphur) (PAF): >3.0% S.

The amount of waste as a proportion of the waste classification over the mine life is shown in Figure 5.4.

### **Management of Organic Waste and NAF Waste Rock**

A 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 filling of the ISF will also be placed in this dump. The Ok Binai waste dump is expected to initially receive 14.3 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 from an elevated ridgeline. Once the ISF has commenced filling in Year 1 most waste rock will be subaqueously deposited in the ISF with an ongoing requirement to place organic waste, topsoil and some NAF waste rock in the spoil dump.



Modelling by Golder Associates (Appendix 5) predicts that the Ok Binai waste dump will gradually erode over a period of approximately 22 years from commencement of its development, i.e., until approximately Year 20 of operations. Sediment eroded from the Ok Binai waste dump will report to the ISF located downstream of the dump.

### **Management of PAF Waste Rock**

The high acid-forming potential of the waste rock requires a robust management strategy to ensure PAF material is stored in a manner that limits exposure to atmospheric oxygen and subsequent formation of AMD.

The International Network for Acid Prevention (INAP) is an organisation of international mining companies dedicated to reducing liabilities associated with sulphide mine materials and AMD. Founded in 1998, INAP has sponsored the preparation of the Global Acid Rock Drainage (GARD) Guide (INAP, 2009), which is intended as a state-of-the-art summary of the best practices and technology to assist mine operators and regulators to address issues related to AMD. According to the GARD Guide (INAP, 2009):

The fundamental principle of ARD [acid rock drainage] prevention is to apply a planning and design process to proactively prevent, inhibit, retard or stop the hydrological, chemical, physical, or microbiological processes that result in the impacts to water resources... Disposal of acid-forming materials below a water cover is one of the most effective methods for limiting AMD generation... because the transport of oxygen through water by advection and diffusion is in the order of 10,000 times slower relative to transport in air.

To limit the potential for generation of AMD from PAF waste rock, SRK designed the ISF to provide a permanent water cover for the waste rock and tailings material. This is termed 'subaqueous deposition' and will limit the risk of AMD that could occur if the PAF waste rock were exposed to air for more than a few months. Section 5.6, Frieda River Hydroelectric Project and Appendix 2, Frieda River Hydroelectric Project Selection Phase Study provide further detail on the design, construction and operation of the ISF.

During the early filling stages of the ISF (i.e., approximately the first 10 months) and 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 reservoir so that the rising water level will inundate the waste rock.

The ISF will ultimately store 1,450 Mt of waste rock subaqueously, of which around 86% is expected to be PAF.

### **Waste Rock Placement**

The majority of NAF and all PAF waste rock will be crushed using rock gyratory crushers to reduce the size of the largest rocks so it can be conveyed 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 1.3), but will have a 27 m vertical operating range to accommodate the fluctuating water levels associated with hydroelectric power generation. A fleet of 5,000 t barges will travel across the surface of the ISF to designated waste rock dumping locations before off-loading waste. The barge latching system in the centre of the barge will be opened to release the waste rock contents. Waste rock will fall through the water column and deposit on the bottom of the ISF.

The location of the deposition of waste rock from the barges into the ISF will be scheduled to achieve an even distribution with a permanent water cover. The average water depth for barge deposition locations will be greater than 40 m. At closure, approximately 40 m of water will be

maintained over the mine waste rock and tailings to prevent resuspension of this material and subsequent transport downstream. Opportunities to revise the minimum water depth will be investigated based on monitoring and further studies during operation of the facility.

#### **5.5.4 Processing**

Ore will be processed in the process plant using conventional comminution (i.e., crushing and grinding) and flotation technology that will produce a copper-gold concentrate slurry. The process plant will be automated with process and engineering data collection and equipment monitoring via a process control system. The process plant will operate 24 hours per day, 365 days per year with approximately two major preventative maintenance shut-downs per year. The process plant will have an average processing rate of 45 Mt/year with a peak of 65 Mt/year in Year 8.

Figure 5.5 shows a schematic of the processing from mine to concentrate load-out. Plate 5.2 shows a comparable but smaller process plant at PanAust's Phu Kham Operation in Laos.

Given the lack of flat land near the mine site, the construction of the process plant will require considerable bulk earthworks to level a pad of sufficient size and geotechnical strength to support the large process plant infrastructure. There are limited areas close to the open-pit and the ISF on which to site the process plant without sterilising potential mineral deposits and without imposing prohibitive cost. The siting and general arrangement of the process plant reflects this trade-off.

The main operations associated with the process plant are:

- Primary crushing, conveying, ore storage and reclaim.
- Primary grinding and pebble crushing.
- Flotation.
- Concentrate thickening and pumping.
- Tailings thickening.
- Reagent and consumable addition.

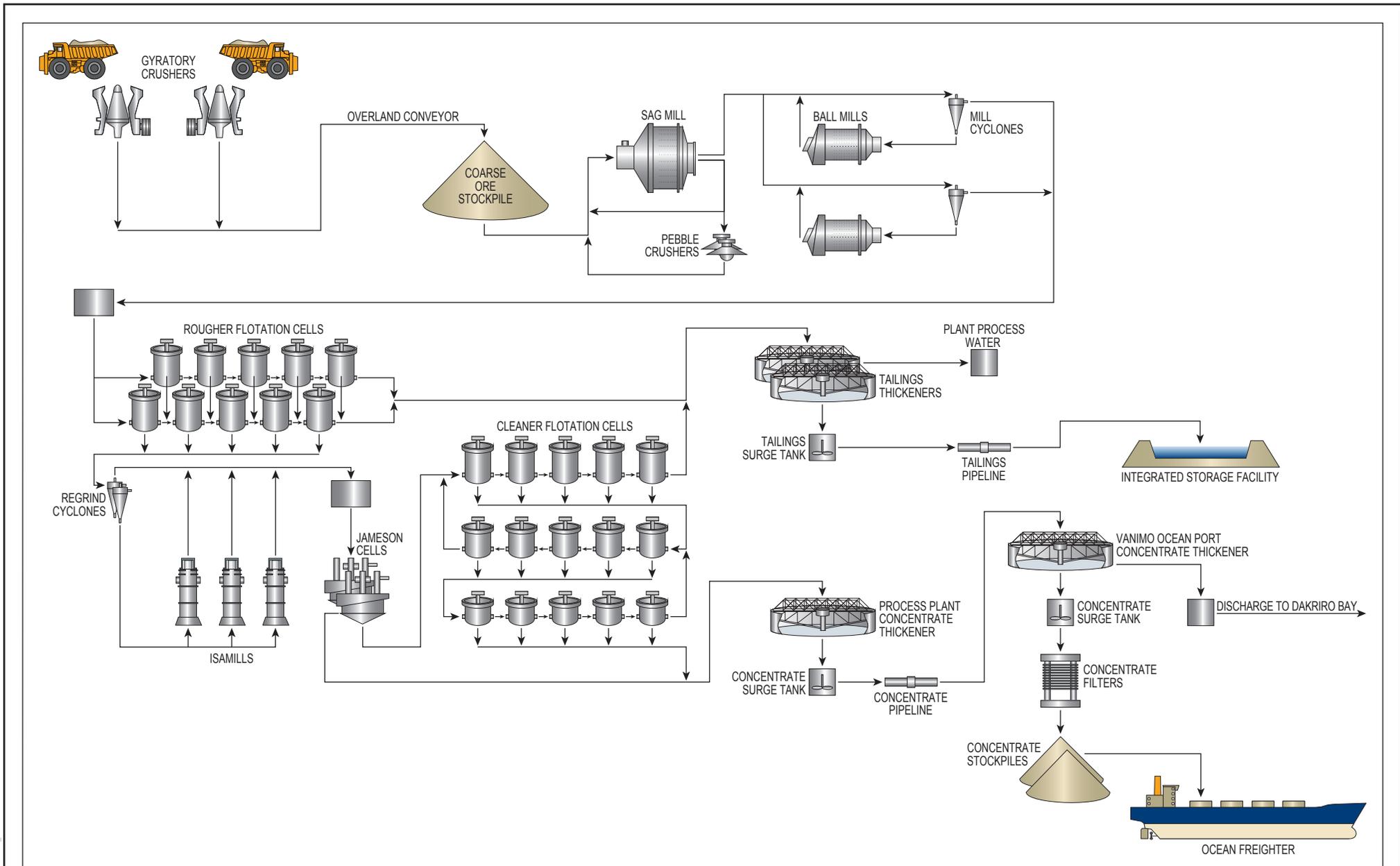
The sulphide mineralisation of the HITEK ore is low in impurities and amenable to sulphide flotation to separate the mineral product from barren tailings. Flotation is primarily a physical process, where flotation reagents are added to the slurry of milled ore to make the mineralised sulphide particles hydrophobic. Frothing agents aerate the slurry and hydrophobic mineralised particles attach to air bubbles and float the particles to the surface, where they are skimmed off as a copper-gold concentrate, leaving the barren minerals to sink to the tailings stream.

The flotation process lifts the copper grade from an average of approximately 0.5% in the mill feed to an average of approximately 26% in the final concentrate.

Material mined from each of the HITEK deposits is expected to be similar with respect to mineralisation and processing requirements.

#### ***Primary Crushing, Conveying, Ore Storage and Reclaim***

Ore from the two ROM hopper pockets (each with 380 m<sup>3</sup> capacity) will gravity feed into gyratory primary crushing units and the crushed ore will be transported via conveyor overland to a coarse ore stockpile. The coarse ore stockpile will have a cover to protect the ore from rainfall. Crushed ore will then be transferred to the process plant by apron feeders which discharge onto the semi-autogenous grinding (SAG) mill feed conveyor. The SAG mill feed conveyor will deliver ore to the process plant.



AI Reference: 11575\_11\_GRA008.at\_5

Source: FRL, 2018



Date: 16.10.2018  
 Project: 754-ENAUABTF11575B  
 File Name: 11575\_11\_F05.05\_GRA

Frieda River Limited  
 Sepik Development Project



Ore processing schematic

Figure No: 5.5

### ***Primary Grinding and Pebble Crushing***

Comminution (crushing and grinding) involves reducing the ore to a particle size suitable for liberation of the target minerals. In the process, ore reclaimed from the crushed ore stockpile will be ground in the primary grinding circuit to reduce its particle size to nominally 80% passing 150 microns ( $\mu\text{m}$ ). The grinding circuit will consist of one SAG mill (28 MW), two ball mills (each 22 MW) and cyclones, all housed in a steel frame metal-clad building. Pebble crushing will be used for SAG mill oversize (reject) material with the crushed product returned to the grinding circuit.

The primary grinding area will be serviced with a large overhead crane and auxiliary crane for maintenance activities.

Ground ore from the SAG milling process will be blended with discharge from the ball mills and pumped as a slurry via two variable-speed cyclone feed pumps to the cyclone clusters. Undersize cyclone material will be directed to a sampling system and on to the flotation and regrind circuit.

In Year 8, an additional SAG mill and two additional ball mills will be required to maintain the throughput rate on harder ores without compromising the grinding product size.

### ***Flotation***

Flotation reagents (lime, frother and rougher-scavenger collector) will be added in stages to the rougher flotation circuit. Frother and collector will be added along the circuit as necessary to control froth development. Rougher concentrate will report to cyclone classification to separate the stream into plus and minus 15 to 20  $\mu\text{m}$  fractions. Cyclone overflow slurry (the smaller fraction) will report to the three Jameson Cells for cleaner scalping, while cyclone underflow slurry (the larger fraction) will gravitate to a regrind mill feed box for regrinding and then onto cleaner scalping flotation cells.

### ***Regrind***

Regrind mills will grind the coarse rougher concentrate to 80% passing 15 to 20  $\mu\text{m}$ . The reground flotation concentrate slurry will be passed to the cleaner flotation circuit, comprising three cleaning units, where a final concentrate product comprising an average of approximately 26% copper will be transferred to the concentrate thickener. Tailings will report to the tailings thickeners.

### ***Concentrate Thickening and Pumping***

Concentrate will be thickened with the aid of flocculant stock solution mixed with process water to assist with settling of the concentrate. The concentrate will feed through a de-aeration unit to the thickener feed well and then be pumped to storage tanks. Overflow solution from the concentrate thickener will be pumped to the SAG mill discharge hopper for re-use.

Concentrate slurry will be pumped 325 km via pipeline from the storage tanks to the concentrate thickener at the Vanimo Ocean Port (see Section 5.7.1). This pumping will require booster stations and further information about this is provided in Section 5.5.9.

### ***Tailings Thickening***

Final tailings will be thickened with the aid of flocculant to approximately 55 to 60% weight per weight (w/w) solids and pumped to the ISF (see Section 5.5.9). The thickening of tailings allows for the overflow water to be collected and reused in the process plant, reducing the raw water requirement for the process plant. It can also reduce the amount of reagents required to be used during processing.

## Reagents and Consumables

Bulk chemicals will be mixed into reagent solutions at the reagent storage facility within the process plant area and distributed to the appropriate areas in the plant. A summary of the consumption and storage requirements for reagents is given in Table 5.11. In general, storage for consumables will be maintained to satisfy a 14-day supply at the process plant.

**Table 5.11 Average reagent consumption and storage quantities**

Reagent	Requirement (kg per tonne of ore)	Consumption (t/year)	Transport volume (t)	Storage volume	
				Process plant	Warehouse (t)
Hydrated lime	1.1	45,300	28	866 t	-
Frother (MIBC <sup>*</sup> )	0.06	2,500	10	20 m <sup>3</sup>	163
Flocculant	0.001	50	20	2,483 m <sup>3</sup>	69
Primary collector (potassium amyl xanthate)	0.06	2,500	20	180 m <sup>3</sup>	167
Secondary collector (dithiophosphate)	0.04	1,600	10	31 m <sup>3</sup>	108

<sup>\*</sup> Methyl isobutyl carbinol.

## 5.5.5 Tailings Characterisation and Placement

### Geochemical Characterisation

As for waste rock described in Section 5.5.3, Waste Rock Management, EGi completed a geochemical characterisation testwork program for tailings. The results of this program are described in detail in Appendix 1 and indicate that final tailings will likely contain between 0.5 and 1.0% sulphur and will be PAF, with only a small inherent neutralising capacity. Testwork also indicates that the lag time for final tailings to generate poor water quality is in the order of a year and may possibly be more.

Tailings will be slurried and pumped to the various deposition points in the ISF by pipeline. The tailings slurry will initially be moderately alkaline as a consequence of lime added during the flotation process. Subaqueous deposition of tailings into the ISF will result in minimal opportunity for sulphide oxidation to occur and, hence, acid generation and/or metals release from the solids should remain negligible.

### Physical Characterisation

The physical properties of a representative sample of tailings were determined from settling test work to inform the design criteria of the ISF. This testwork was completed by SRK and the results are described in detail in Appendix 2a. Further physical testwork will be undertaken during detailed design but this is not expected to reveal any significantly different properties.

The physical tailings properties derived from SRK's testwork are:

- Soil particle density (specific gravity (SG)): 2.6 tonnes per cubic metre (t/m<sup>3</sup>).
- Average slurry density: 55 to 60% solids w/w.
- Permeability:  $1 \times 10^{-7}$  metres per second (m/s).
- Average settled tailings density: 1.1 t/m<sup>3</sup> (dry bulk density) to 1.4 t/m<sup>3</sup>.

### Tailings Placement

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 section. The pipeline will be extended by 6 km in approximately Year 5. The pipeline will be designed to handle the

required pressure and volume and will have pressure transmitters and flow meters to detect leaks or blockages.

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 (the upper layer of water), to minimise potential suspension of tailings. The location of the deposition pontoon will be moved periodically to maximise settling and consolidation of tailings. This will typically result in the tailings being deposited in thin uniform layers over a large area.

### 5.5.6 Water Management

The mine area is located in a high rainfall / high runoff environment with annual falls in excess of 8,000 mm. The water management objectives for the FRCGP are: i) to contain fugitive sediments to levels consistent with the natural sediment regime of the rivers downstream of the ISF; and ii) to prevent acid formation in mine waste and tailings emplacements.

The approach to water management for the FRCGP was developed by SRK and is described in the site wide water balance report (Appendix 6a). This work first required the preparation of the water balance model which was then used in the load balance model to provide water quality predictions for creeks and rivers downstream of the mine and ISF. The outcomes from these models informed the water management strategy for the FRCGP, which was an iterative process to determine the optimum design that would meet both the economic and environmental objectives for the Project.

Water management for the ISF is described in Section 5.6.8, Water Management.

There will be four key water storages for the FRCGP. Table 5.12 provides the purpose and size of these storages.

**Table 5.12 Summary of water storages**

Water Storage	Purpose	Capacity
Open-pit water sumps	To manage runoff to the open-pit and groundwater inflow	1,500 megalitres (ML) from Year 5
Raw water tank	To receive water from the ISF for general non-potable consumption	3.2 ML
Process water tank	To receive water from the ISF for the process plant	3 ML
ISF	Storage of waste rock and tailings	9.6 Bm <sup>3</sup>

The following sections present the key aspects of the surface water management during operations and closure.

## Operations

### *Water Demand*

During operations, the primary water demand for the site will be from ore processing and potable water requirements. The mine water system will be configured to maximise the fit-for-purpose use of water on site with the aim of using water efficiently. Table 5.13 presents a summary of the demands for the operation and the corresponding volume of water.

**Table 5.13 Operational water demand**

Demand	Volume (ML/day)
Process water demands	110
Potable water	1.0

Two water treatment plants will be constructed at the accommodation villages to meet potable water demands:

- Mine site accommodation village – mean daily flow of approximately 1.0 ML/day with a design capacity of up to 1.7 ML/day, supplied from the Nena river.
- ISF accommodation village – mean daily flow of approximately 1 kilolitre per day, supplied from local rivers.

During operations, process water will be sourced from the ISF via a floating pump station and will be discharged into raw water tanks located at the process plant.

A schematic of the conceptual water management strategy during operations is shown in Figure 5.6.

### ***Open-pit Sumps***

Open-pit wall runoff is expected to be of poor quality due to the presence of PAF material in the exposed wall and in fragmented material on the open-pit benches. This contact water will report to two sumps within the open-pits, one in the HIT and Ekwai open-pit and one in the Koki open-pit. Open-pit sumps will be used to store contact water prior to being transferred to the water treatment plant.

### ***Groundwater Inflow***

The excavation of the open-pit to depths in excess of 400 m below the open-pit exit will intersect local groundwater flow. The open-pit will act as groundwater ‘sinks’ and groundwater will collect in the open-pit sumps during mining. The rate of groundwater flowing into the open-pit was calculated by Australasian Groundwater and Environmental Consultants (AGE), with the results presented in Appendix 4. This rate is expected to vary throughout the mine life, as shown in Table 5.14.

**Table 5.14 Groundwater inflow rates**

Year	Groundwater inflows (ML/year)		
	HIT	Ekwai	Koki
2	2,640	100	0
5	4,090	600	440
10	5,120	460	990
15	6,690	380	900
25	8,460	570	770
33	8,780	520	800

### ***Open-pit Dewatering***

The volume of water entering the open-pit will progressively increase during the mine life with open-pit catchment areas expanding as mining progresses. Open-pit water management will



include staged development of the open-pit, maintenance of working levels above the open-pit sumps and containment of all mine water within the open-pit during operations. Average open-pit sump pumping rates of 65 ML/day for the HIT and Ekwai open-pit and 6.3 ML/day for the Koki open-pit are estimated. To manage peak dewatering demands associated with rainfall events, maximum pumping rate capacities of up to 123 ML/day and 9.2 ML/day will be installed within the HIT and Ekwai open-pit and Koki open-pit, respectively. Clean water diversions will be constructed upslope of open-pit areas to divert water around mining areas and reduce dewatering and water treatment requirements.

### ***Open-pit Water Treatment***

The open-pit water quality is expected to be poor due to the exposure of PAF material in 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 quicklime or hydrated 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 further dilution prior to entering the downstream environment.

The conceptual lime dosing rates to treat open-pit water during operations are listed in Table 5.15. Testwork and modelling reported in Appendix 6a shows that as open-pit development progresses and water flow and acidity increases during operation, the lime dosing rate will need to increase. Sludge generated from treatment of the open-pit water will be pumped to the tailings thickener at the process plant for final disposal with tailings into the ISF.

**Table 5.15 Lime dosing rates for open-pit water treatment**

<b>Year</b>	<b>Quicklime as calcium oxide (tonnes/day)</b>	<b>Hydrated lime as calcium hydroxide (tonnes/day)</b>
Operation		
1	4	5
2	6	8
3	9	12
4	11	15
5	13	18
6	16	22
7	22	29
8	27	36
9	32	43
10	35	46
15	49	65
20	65	86
25	74	98
33	72	96
Closure		
34 to 36	-	-
37	55	73
38	53	70
39	51	67

**Table 5.15 Lime dosing rates for open-pit water treatment (cont'd)**

Year	Quicklime as calcium oxide (tonnes/day)	Hydrated lime as calcium hydroxide (tonnes/day)
Closure (cont'd)		
40	49	65
45	41	55
50	38	51
55	38	51

Source: Appendix 6a

### **Concentrate Filter Plant**

Concentrate slurry will be transported by pipeline from the process plant to the Vanimo Ocean Port. The slurry will be thickened and filtered at the port to produce the concentrate for export. Overflow water from the thickener will be used for washdown with the excess being treated through the water treatment plant for discharge to the environment. Approximately 55 litres per second (L/s) of treated process water will be discharged into the ocean as a result of concentrate thickening and filtering. Minimal water will be retained in the final concentrate product, which is expected to have 9.5% moisture content to ensure safe shipping (i.e., it will be below the transportable moisture limit of approximately 12%).

### **Closure**

Mine infrastructure without a future beneficial use will be removed following the end of operations. A pit lake and the ISF will remain. A schematic of the conceptual water management strategy during closure of the FRCGP is presented in Figure 5.7. Further closure details for the FRCGP are provided in the FRCGP Conceptual Mine Closure Plan (Appendix 3a).

### **Open-pit**

The open-pit will slowly fill to a level of RL 440 m from groundwater inflow and direct rainfall. The open-pit is expected to take three years to fill assuming the diversion drains around the pit are directed into the open-pit to accelerate filling.

Once the final void fills, excess water will be treated prior to discharge to Ubai Creek. The open-pit lake will cover approximately 40% of the surface area of the final HITEK open-pit.

### **Groundwater**

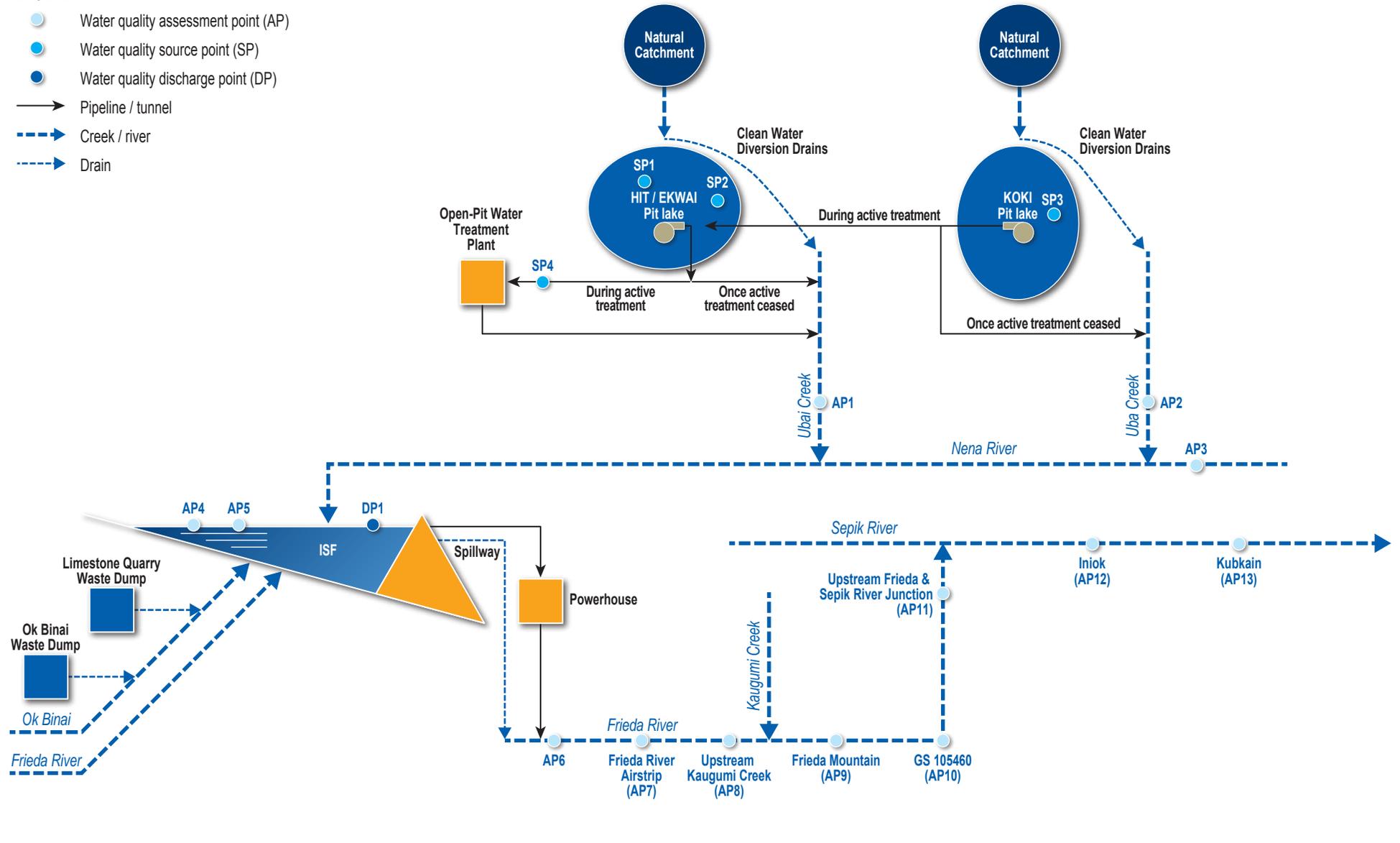
Groundwater inflow is expected to continue to occur following mine decommissioning and will reduce over time as the open-pit fills to capacity. Modelling indicates that the open-pit will act as a groundwater sink rather than a groundwater source.

### **Post Closure**

Water discharged from the flooded open-pit lake will continue to be treated prior to release to Ubai Creek until downstream water quality criteria can be met without treatment. Modelling of sulphide depletion in the pit walls predicts this will take at least 50 years post closure (Appendix 6a). Regular post closure monitoring and maintenance will be undertaken as completion criteria are progressively achieved and sustained.

**LEGEND**

- Water quality assessment point (AP)
- Water quality source point (SP)
- Water quality discharge point (DP)
- Pipeline / tunnel
- Creek / river
- Drain



Source: FRL, 2016



Date: 24.09.2018  
 Project: 754-ENAUABTF11575B  
 File Name: 11575\_11\_F05.07\_GRA

Frieda River Limited  
 Sepik Development Project



Conceptual mine water balance schematic - FRCGP closure

Figure No: 5.7

## **5.5.7 Power Supply**

### **Power During Construction**

Power during construction will be provided by diesel generators located at major infrastructure locations including the open-pit, mine infrastructure area, process plant and site accommodation village. During the final year of construction the FRHEP will be commissioned and power will be used for wet commissioning the process plant.

### **Power During Operations**

Power during operations will be provided by hydroelectric power generation from the FRHEP (Section 5.6.12, Hydroelectric Power Generation). The powerhouse will supply power via a dedicated 22-km-long 132 kV transmission line to the process plant.

The mine's power demand will be approximately 180 MW increasing up to 280 MW by Year 8. Additional power will be required for FRCGP off-site facilities including the Vanimo Ocean Port and Vanimo Infrastructure Area (4 MW) and two concentrate pipeline booster pump stations (7 MW). This power will initially be supplied from diesel generators and then will be supplied via the Northern Transmission Line from Year 4, which is part of the SPGP.

### ***Transmission Line***

The 22-km-long transmission line from the powerhouse to the process plant will sit within a nominal corridor 40 m wide and will be strung on approximately 63 self-supporting galvanised lattice steel towers.

The transmission line route was based on the shortest feasible route, access availability for construction and maintenance, following contours and avoiding high ridges wherever possible, avoiding areas of possible inundation and poor foundation conditions.

The transmission line towers will be located as close as practical to the link road between the powerhouse and the process plant substation. Short access tracks will be constructed from the link road to service the transmission tower locations.

### **Power Distribution**

A substation will be located at the process plant and power will be distributed through 33 kV overhead lines and buried cables.

### ***High Voltage Distribution***

The main high voltage (HV) substation located at the process plant will be developed in stages to ensure power supply during planned and unplanned maintenance periods with availability of delivered power in excess of 99.75%. The 132/33 kV process plant substation installed capacity will increase from 255 MVA to 425 MVA in Year 8.

### ***Medium Voltage Distribution***

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 substation. Overhead distribution lines will reticulate power from the MV substations to the following facilities:

- Site accommodation village.
- Administration and training.
- Explosives storage.
- Mine infrastructure area.
- Waste management facilities.

## **Emergency Power**

Emergency power will be supplied to essential services at the process plant and other facilities, including the site accommodation village.

A total of 30 MVA of emergency standby diesel generators will be installed at the site accommodation village in the mine area to provide emergency power or supplement power generation if hydroelectric generators are temporarily not operational.

The diesel generators will be connected directly to the 33 kV distribution network.

## **5.5.8 Ancillary Infrastructure**

### **Accommodation**

On-site accommodation will be constructed for a peak of up to 3,550 personnel during construction and permanent accommodation for approximately 2,780 personnel.

The construction camp and site accommodation village will be located on the mine access road between the process plant and the HITEK open-pit. It will be built initially to service construction and later refurbished to cater for the operations workforce. It will comprise two storey accommodation units, kitchen, dining room facilities and recreational facilities, the first aid and medical centre and training room. The village administration building will have an adjacent covered bus station and will include the central control room (integrated mine, process and logistics functions), offices, muster areas and training facilities.

Raw water will be pumped via a pipeline from the Nena River (300 kL/d) for general non-potable consumption at the site accommodation village. The potable water treatment plant, located at the highest point in the site accommodation village and administration facility, will be fed from the raw water tank and will enable gravity flow to the site accommodation village and administration area via a dedicated reticulation system. This facility will also supply the process plant and MIA. Fire water for the site accommodation village and other facilities at the mine will also be sourced from the potable water tanks.

The sewage treatment plant will be located at the lowest point in the camp to allow gravity sewer drains to be used as much as possible within the facility. The network will consist of gravity sewers with pumped rising mains where required. The sewage treatment plant specifications will cater for 300 L/person/day based on peak personnel requirements.

### **Spoil Dumps**

Spoil material from foundation excavations and road cuttings will be placed in dedicated spoil dumps. Vegetation and organic material stripped from the site construction areas will also be stored within the spoil dumps.

The spoil dumps will be located within the ISF catchment and will generally be designed with stormwater and sediment management infrastructure to limit the release of coarse-grained sediment from the construction site. The limestone quarry waste dump is the exception as this will be an eroding dump into the Ok Binai. 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 5 Mm<sup>3</sup> (10 Mt) of spoil over two years and is expected to gradually erode until depleted in Year 20 of operations (Appendix 5). Once impoundment occurs, fugitive sediment will report to the ISF.

## Roads

The public road (from Vanimo to Hotmin) and mine access road will enable passenger and freight access during construction and operation of the mine. Containerised and break-bulk cargoes will be transported from the Vanimo Ocean Port to the mine site using a fleet of trucks, typically operating in a convoy arrangement up to 24 hours per day.

The main haul road will be established for haul trucks (Plate 5.1) to transport ore and waste from the open-pit to the ROM pad, the Ok Binai waste dump and waste rock crushing facility. The haul road will consist of 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 220 t dump trucks.

Access roads for the mine comprise the:

- Mine access road – a 39-km-long, dual-lane, unsealed road (nominally 7.5 m wide) will run from the termination point of the public access road on the eastern side of Hotmin to the site accommodation village.
- Link road – a 33-km-long, dual-lane, unsealed road (nominally 7.5 m wide) will run from the site accommodation village to the powerhouse.
- 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.

Six bridges will be required along the access roads and conveyor corridor. The access roads will require approximately 2.7 Mm<sup>3</sup> of cut which will either be sidecast (60%) or disposed to the dedicated spoil dumps (40%).

Road construction materials will be sourced from new quarries to be developed adjacent to the road corridor and from the diorite quarry.

## Quarries

Construction material for earthworks will be sourced from a number of quarries. This material will be used for the construction of dams, roads, water diversion bunds and infrastructure pads. Where practicable, the construction quarries will be located within or directly next to proposed infrastructure footprints to limit haul distances and to concentrate impacts associated with their development into catchments already disturbed by the mine or other Project components.

Competent rock for the haul road construction, maintenance and blast hole stemming will be sourced from a diorite quarry located east of the HITEK open-pit.

A limestone quarry located southeast of the HITEK open-pit will provide limestone for the water treatment plant and also for the process plant. Excavated limestone will be stored in a stockpile next to the limestone quarry.

## Communications

Site-wide communications, information technology, fire services and security links will be via a fibre optic network linking all facilities.

A fibre optic cable will be run with overhead lines and underground 33 kV power reticulation to each facility. Similarly, a fibre optic cable will run along the concentrate pipeline enabling communications between the process plant, booster pump stations and the concentrate filter plant at the Vanimo Ocean Port.

A satellite link will be installed in the mine area for communications during construction and will be retained during operations as a back-up to the fibre optic network.

### **5.5.9 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 (Figure 5.8). These are described below.

#### **Concentrate Export Route**

Concentrate will be transferred between the processing plant and the Vanimo Ocean Port through a buried 325-km-long pipeline within the infrastructure corridor. Two concentrate booster pump stations will be located along the concentrate export route to maintain pressure in the concentrate pipeline. One will be located near Green River and one will be located approximately 5 km to the south-west of Itomi.

#### **Concentrate Export Facility**

The concentrate export facility will be developed at the Vanimo Ocean Port. This will comprise dedicated facilities for concentrate dewatering and handling, including:

- Concentrate thickener and filter plant.
- Concentrate storage shed.
- Ship loading facility.
- Water treatment plant.
- Bulk diesel pipeline.
- Diesel generators.

#### **Concentrate Thickener and Filter Plant**

Concentrate from the pipeline will be delivered to the concentrate thickener via a feed de-aerator. Thickened concentrate will then be pumped to horizontal plate filters before being discharged into the bulk concentrate storage shed ready for shipment. Filtrate from the concentrate filter will be collected in a filtrate hopper, prior to being returned to the concentrate thickener.

A small workshop will be incorporated into the structure for maintenance of the fixed plant.

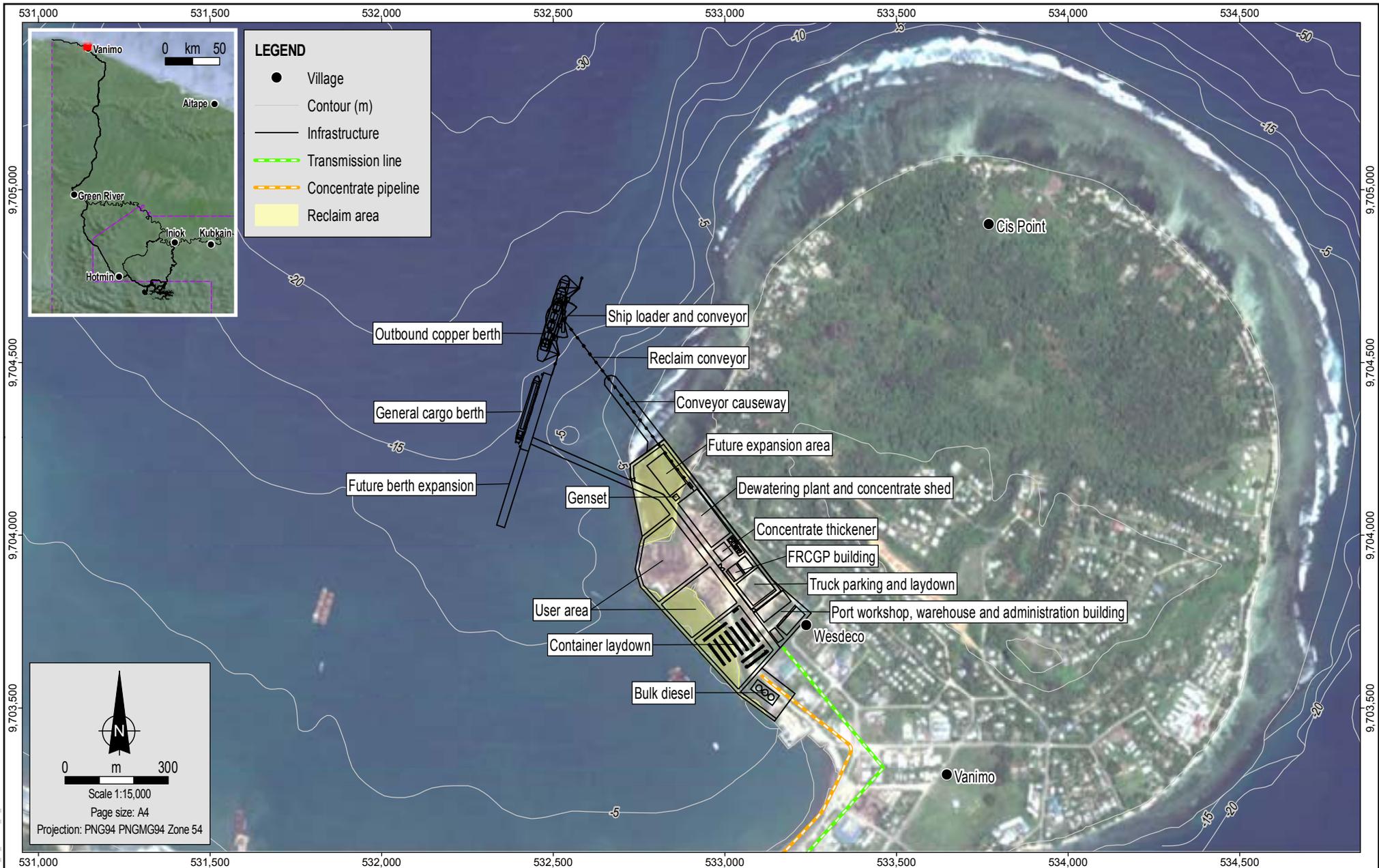
#### **Concentrate Storage and Ship Loading**

The concentrate storage shed will be used as a buffer storage and blending facility with a storage capacity of 80,000 t of copper concentrate. A reclaim conveyor will deliver the filter cake from the concentrate storage shed to the ship loader. The conveyor will be covered and will be approximately 620 m in length. Dust reducing measures will be implemented, such as using minimum drop from transfer heights, negative pressure and ventilation in the storage shed, and scrapers on the return belts.

The berth will accommodate the loading, unloading and manoeuvrability of an ocean going bulk carrier in the range of 28,000 dwt to 48,000 dwt (Handysize to Handymax).

#### **Water Treatment and Handling**

A water treatment plant will be located at the port for treatment of concentrate thickener overflow. The water treatment plant will be designed to ensure water quality meets the environment permit criteria at the boundary of a designated mixing zone (see Section 8.10).



**LEGEND**

- Village
- Contour (m)
- Infrastructure
- Transmission line
- Concentrate pipeline
- Reclaim area



0 m 300

Scale 1:15,000  
Page size: A4  
Projection: PNG94 PNGMG94 Zone 54

MXD Reference: 115756\_11\_GSD018\_v0\_3

Source:  
Transmission line and concentrate pipeline from FRL.  
Port layout and reclaim areas from GHD.  
Villages from FRL and Coffey.  
Contours from BMT WBM.  
Imagery from Google Earth (DigitalGlobe captured 14 December 2014).

**coffey**  
A TETRA TECH COMPANY

Date: 16.08.2018  
Project: 754-ENAUABT11575A  
File Name: 11575 11 F05.08 GIS

**Frieda River Limited**  
**Sepik Development Project**

**FRIEDA RIVER**

**Vanimo Ocean Port**

Figure No:  
**5.8**

## **Diesel Handling**

Bulk diesel will be unloaded from international tanker vessels and stored in the bulk diesel storage facility at the Vanimo Infrastructure Area. The bulk diesel unloading system (cargo berth and unloading pipeline) is included in the SIP. A pipeline will be constructed from the Vanimo Ocean Port to the Vanimo Infrastructure Area to store fuel prior to transportation to the FRCGP.

## **Temporary Power Generation**

The Vanimo Ocean Port will be powered by diesel generation for the first year of operation. From Year 2, these facilities will be connected to the Northern Transmission Line by a 2-km-long, 33 kV overhead distribution line from the Vanimo substation and diesel power will be for emergency only.

General facilities at the Vanimo Ocean Port that will be developed for shared-use are detailed in Section 5.7.1.

## **Vanimo Infrastructure Area**

A multi-purpose infrastructure area will be established in Vanimo to support the FRCGP. The Vanimo Infrastructure Area will be adjacent to the main access route and have convenient road access to the Vanimo Ocean Port. The Vanimo Infrastructure Area will be fenced with access control and security checkpoints and will include:

- FRLs regional office with workspace for up to 50 employees (0.1 ha). The main office will include a basic medical clinic and emergency response vehicle parking.
- Permanent accommodation for senior staff including provision for 40 houses, recreation facilities and security (6 ha).
- Hotel-style accommodation for night shift workers (6 ha). The accommodation village will include a small administration office, kitchen, mess, laundry and recreation facilities.
- A warehouse and laydown yard for transit freight storage (2 ha). This will allow for storage of approximately 1,100 containers, including refrigerated containers.
- A maintenance workshop for the logistics haulage fleet and mobile equipment.
- Up to 24 ML of diesel stored in tanks located in a bunded area with suitable structural foundations. A truck loading system will transfer diesel from the storage tanks to tankers which will deliver the diesel to the MIA for the FRCGP. A vehicle refuelling point will be located on a bunded concrete slab, suitable for heavy and light vehicles.

Land adjacent to the Vanimo Infrastructure Area will initially be used for construction laydown and support facilities and subsequently converted into vendor workshops and warehouses to provide support for operations. Up to 3 ha of development area will be available for major vendors to establish workshops and warehouses to support the Sepik Development Project.

All buildings developed in the Vanimo Infrastructure Area will be reticulated with power, communications, water and sewerage. Fire water ring mains, fire hydrants, safety showers and stormwater treatment will also be provided.

### **5.5.10 Decommissioning and Rehabilitation**

A conceptual closure plan for the FRCGP has been prepared that describes decommissioning and rehabilitation concepts consistent with the level of detail available for this phase of the Project

(Appendix 3a). This section provides a summary of the goals and concepts described in that plan. The decommissioning and rehabilitation concept for the FRHEP is provided in Section 5.6.

FRL's goal for closure is to rehabilitate disturbed areas in a manner that, where possible, will support self-sustaining vegetation that is consistent with that of surrounding natural areas and to leave a lasting positive legacy for impacted communities in the form of transferred skills and self-sustaining community development programs.

Decommissioning will commence after mining operations have ceased and is expected to take three years. It will involve the removal of infrastructure, facilities, equipment and services, unless otherwise agreed with stakeholders. A further 10 to 20 years of post closure monitoring and maintenance will be undertaken as completion criteria are progressively achieved and sustained. Active water treatment will be required during this time and infrastructure will be needed to support this.

FRL may come to an agreement to transfer some 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 the point of transfer.

The conceptual closure plan conservatively assumes that all FRCGP assets which are not required after relinquishment will be demolished.

For the purposes of developing a closure framework that comprises closure objectives, completion criteria and closure indicators (i.e., minimum measurable value to be achieved) the FRCGP facilities have been split into domains, as is commonly done in mine closure planning. Further details are presented in Appendix 3a.

Preliminary end land uses for each domain are summarised in Table 5.16.

**Table 5.16 Proposed end land uses for closure domains**

Domain	Project component	Preliminary proposed end land use option
Open-pit and quarries	<ul style="list-style-type: none"> <li>• Open-pit.</li> <li>• Quarries.</li> </ul>	<p>Open-pit lake with exposed high walls surrounded by landscape rehabilitated similar to surrounding vegetation.</p> <p>Quarries are likely to remain as permanent landscape components. Some quarries may have an associated quarry lake.</p>
Mine infrastructure	<ul style="list-style-type: none"> <li>• ROM and primary crushing facility.</li> <li>• Conveyor system and crushed rock stockpiles.</li> <li>• MIA.</li> <li>• Process plant.</li> <li>• Haul roads.</li> <li>• Raw water pipeline.</li> <li>• Explosives magazine.</li> </ul>	<p>Infrastructure will be decommissioned and removed where possible.</p> <p>Rehabilitated landscape that is similar to surrounding vegetation.</p>
Ok Binai and limestone quarry waste dumps	<ul style="list-style-type: none"> <li>• Ok Binai Valley waste dump.</li> <li>• Limestone quarry waste dump.</li> </ul>	<p>Rehabilitated landscape that mimics recovery after a natural landslip (i.e., revegetated via natural regeneration).</p>

**Table 5.16 Proposed end land uses for closure domains (cont'd)**

Domain	Project component	Preliminary proposed end land use option
Tailings pipeline and waste rock barging facilities	<ul style="list-style-type: none"> <li>Tailings pipeline.</li> <li>Waste rock barging and loading facilities.</li> </ul>	Infrastructure will be decommissioned and removed where possible.
Transmission line and substation	<ul style="list-style-type: none"> <li>Transmission line.</li> <li>Substation.</li> </ul>	Infrastructure will be decommissioned and removed where possible.* Rehabilitated landscape that is similar to surrounding vegetation.
Access and infrastructure corridor	<ul style="list-style-type: none"> <li>Mine access road.</li> <li>Link road.</li> <li>Concentrate pipeline.</li> <li>Spoil dumps.</li> </ul>	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	<ul style="list-style-type: none"> <li>Concentrate export facility.</li> </ul>	Concentrate export infrastructure will be decommissioned and removed where possible.* Land rehabilitated to meet future land use as agreed with Vanimo Ocean Port operator.
Ancillary infrastructure	<ul style="list-style-type: none"> <li>Accommodation villages.</li> <li>Administration building.</li> </ul>	Accommodation villages and administration infrastructure will be decommissioned and removed.* Rehabilitated landscape that is similar to surrounding vegetation.

\* With the exception of infrastructure transferred to a third party.

In general, the following will be undertaken at the completion of mining:

- Remove mobile equipment.
- Dismantle or economically demolish remaining equipment, infrastructure and services.
- Remove salvageable materials from site and sell as scrap for recycling. 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 landfills or voids. Such materials will probably include concrete foundations, miscellaneous building materials and tyres.
- Dismantle and remove the substation and transmission line.
- Fracture concrete structures and foundations to promote infiltration and cover 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.
- Leave in situ subsurface pipelines if they cannot be economically salvaged or where their recovery is likely to result in adverse environmental impacts. 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.

As part of decommissioning, the following infrastructure will remain on site:

- The HITEK open-pit will be allowed to flood to approximately RL 440 m, which will be below the elevation of the open-pit overflow of RL 449 m on the north-western side of the open-pit. Under average climatic conditions, and assuming active filling, the open-pit is expected to flood within three years and, when fully formed, the open-pit lake will cover approximately 40% of the surface area of the final open-pit. There will be a high wall exposed above water level (approximately 600 m high) that is expected to contain acid forming material. Modelling by SRK (Appendix 6a) predicts that active water treatment is expected to be required throughout the life of the mine and continue for approximately 50 years after mine closure to ensure downstream water quality criteria are met. Surface water diversion drains around the open-pit will be maintained while there is active water treatment.
- The mine access road and the link road will be maintained during the closure monitoring period to allow access to the ISF, accommodation village and water treatment plant. These roads will be transferred to the FRHEP at relinquishment.

## 5.6 Frieda River Hydroelectric Project

The ISF will be constructed in the Frieda River catchment approximately 16 km downstream of the mine and 35 km upstream of its confluence with the Sepik River, and will have an ultimate footprint of approximately 12,700 ha. Along with the large HITEK open-pit void, it will be the most prominent feature of the Project. The objectives of the FRHEP are to:

- Produce power for the Project.
- Safely store tailings and waste rock produced by the mining and ore processing operation.
- Produce excess power for potential third party users.

The international engineering consultancy, SRK, designed the FRHEP and its design report is provided as Appendix 2a. This design has been subject to international expert peer review by PanAust's Tailings Independent Review Panel (TIRP), which has been established to assess the adequacy of the FRHEP design and the underlying studies informing this design, and to provide recommendations on additional studies or evaluations to address areas of uncertainty.

The ISF was designed as a large water dam rather than using conventional tailing storage facility design principles (see Appendix 2a). This design philosophy was adopted by FRL due to the recognition of the risks associated with potential seismic activity in the Project area, the high rainfall, and the necessity for the structure to remain stable under such conditions.

The consequence of an embankment failure is classified as potentially "Extreme" under guidelines provided by ANCOLD and the International Commission on Large Dams (ICOLD), and as such, appropriate design standards and criteria have been selected.

The FRHEP was designed by SRK to provide sufficient power for the FRCGP plus export power capacity to support the SPGP. The ISF also provides sufficient combined storage capacity for process tailings, mine waste rock, natural sedimentation and surface water from the Frieda River catchment, while keeping the tailings and PAF waste rock permanently submerged under all foreseeable conditions. This is important because the geochemical characterisation of the waste rock and tailings (Sections 5.5.3 and 5.5.5, respectively) shows that the material would become

acid-forming if exposed to atmospheric conditions over short to medium timeframes, with potential impacts to downstream water quality.

PanAust also uses subaqueous deposition for its tailings and waste rock storage facility to manage the potential for AMD at its Phu Kham Operation in Laos (Plate 5.3).

Figure 5.9 shows the final layout of the FRHEP, which will comprise:

- Diversion channel.
- Diversion dam.
- Diversion tunnels and tunnel portals.
- Cofferdams.
- Environmental low flow release infrastructure.
- Intermediate intake.
- Hydroelectric power infrastructure.
- Operational spillway.
- Quarry (for embankment construction material).
- Main embankment.
- Spoil dump/s.

This section describes the construction and operation of the FRHEP in detail.

### **5.6.1 Diversion Tunnels**

Two tunnels will be required to divert river flows from the Frieda River away from the construction area of the embankment while providing protection against 1:100 storm events. The diversion tunnels, approximately 1,300-m-long, will consist of two 9 m x 9 m shotcrete-lined tunnels located on the eastern bank (i.e., the right abutment looking downstream) of the Frieda River.

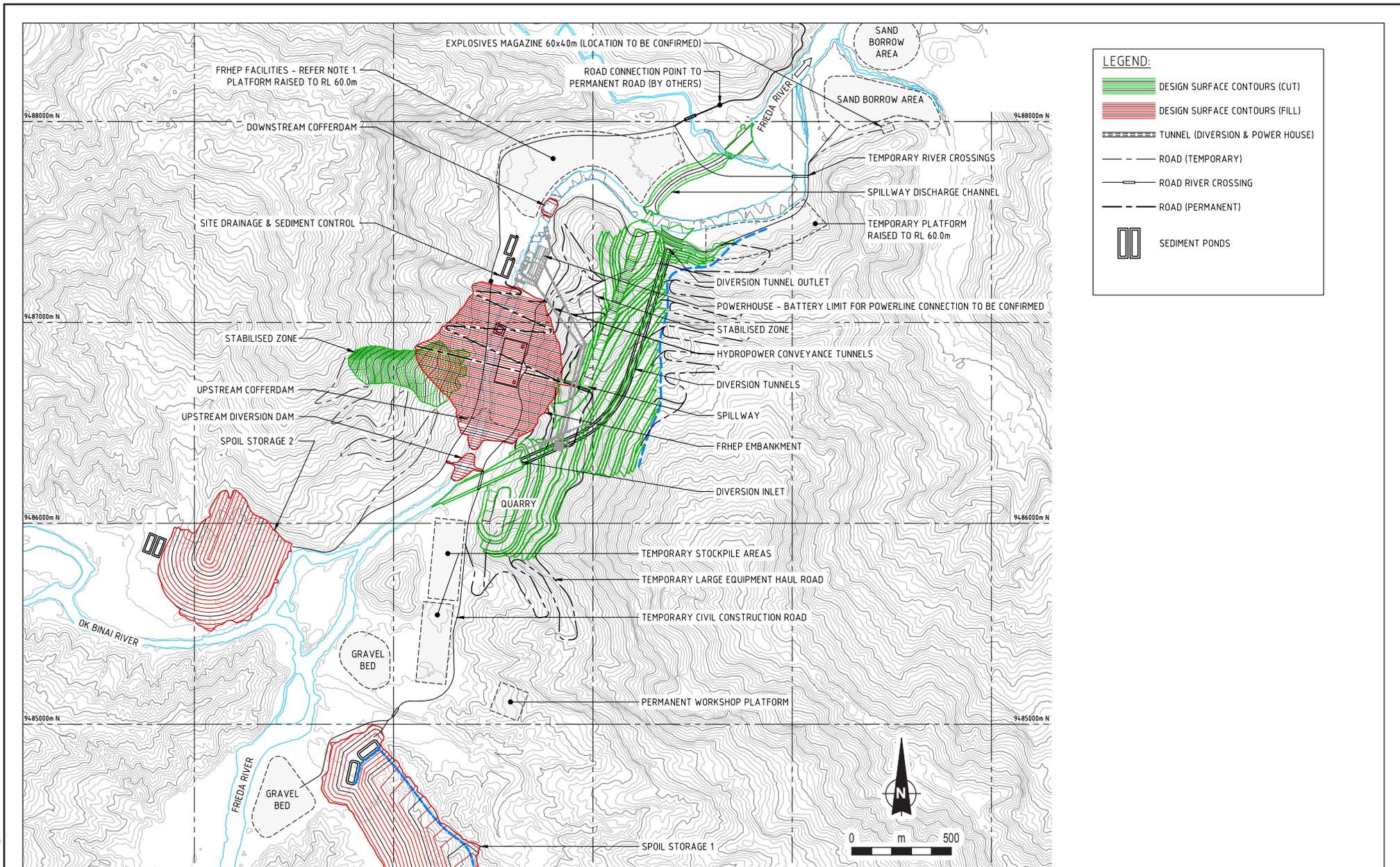
A diversion dam and cofferdam will be located upstream of the embankment construction area, with the inlet of the diversion tunnels directly upstream of the diversion dam at RL 56 m. Sediment ponds and a cofferdam will be located downstream of the embankment construction area, with the diversion tunnel outlets approximately 700 m downstream of the cofferdam. The Frieda River will be diverted to flow into the diversion tunnels after the two tunnel ends are connected to the inlet and outlet works and the upstream diversion dam and downstream cofferdam are constructed. The upstream cofferdam will then be completed.

### **5.6.2 Embankment**

Following the completion of the diversion tunnels and cofferdams, the embankment will be constructed in a single phase and will incorporate the main upstream cofferdam. The embankment will be constructed as a rock fill embankment with a thick central asphalt core. The core will range from 1.7 m thick at the base to 1.0 m thick at the crest. Asphalt has been selected for its plastic properties and its ability to deform with the slope without significant cracking occurring under the anticipated site seismic conditions.

Filter and transition zones will be constructed upstream and downstream of the central asphalt core. The width of the filter and transition zone and the asphalt core was determined based on the predicted deformations that are likely to occur following an earthquake event.

The embankment wall will be constructed with engineered rock fill material with an upstream slope of 1.7H:1V and a downstream slope of 1.2H:1V. The foundation for the dam will be excavated to bedrock, typically to a depth of about 2 to 5 m, except in the central portion of the



Source: PNA009-0020 SITE GENERAL ARRANGEMENT.pdf, SRK



Date: 05.10.2018  
 Project: 754-ENAUABTF11575B  
 File Name: 11575\_11\_F05.09\_GRA

Frieda River Limited  
 Sepik Development Project



ISF embankment layout

Figure No: 5.9

AI Reference: 11575\_11\_GRA02.ai\_6



Photo credit: PanAust

**Plate 5.1**  
Haul trucks



Photo credit: PanAust

**Plate 5.2**  
Construction of the process plant at  
PanAust's Phu Kham Operation in Laos



Photo credit: PanAust

**Plate 5.3**  
Phu Kham tailings storage facility

valley. Rock fill will be sourced from a dedicated quarry, while filter and drain material will be river gravels supplemented with quarried material as required. Bitumen for the asphalt liner will be imported to site.

Embankment seepage will be managed through the installation of a plastic cement cutoff wall, to provide a ductile low permeability barrier, and a grout curtain. Where geotechnical structures have been identified beneath and in the abutments of the embankment, fault grouting will be carried out to limit seepage through the plinth and through the abutments.

Construction of the embankment will continue over approximately three to four years to achieve a final crest elevation of RL 238 m with a maximum wall height of 190 m. The ISF is designed to accommodate 9.6 Bm<sup>3</sup> which provides water storage to generate 2,800 GWh/year (up to 490 MW) of power and capacity for 1,500 Mt of tailings, 1,450 Mt of waste rock and 44 Mt of sediment over the life of the mine. Post closure, there will be many hundreds of years of additional storage capacity for sediment based on current loads.

The dam crest elevation will allow storage of water from a probable maximum precipitation (PMP) 72-hour rainfall event, which at Frieda River is 1,350 mm. For comparison, the highest 24-hour rainfall event recorded within the Frieda River catchment is 304 mm at the Upper Nena rainfall gauge.

Intake tunnels will be located at three levels to facilitate environmental release flows during filling (RL 70 m), to allow commissioning of turbines and early power generation if required (RL 143 m) and for normal power generation (RL 186 m). The lower level intake will be valved and connected to the diversion tunnels, to allow the release of environmental flows of 50 m<sup>3</sup>/s, and will be sealed once the powerhouse is built. The minimum environmental flow has been allowed for to sustain the downstream aquatic ecosystem of the Frieda River. The two upper intakes will be connected to the powerhouse and will have by-pass valves to allow release of environmental low flows during operation at times when no power is being generated. The mid-level intake will also be sealed once the dam is in operation.

Early filling of the reservoir will commence approximately three months prior to completion of the construction of the embankment. Hydroelectric power generation will commence four months following the commencement of filling once the water level reaches the mid-level intake tunnel.

Figure 5.10 shows the embankment in cross section.

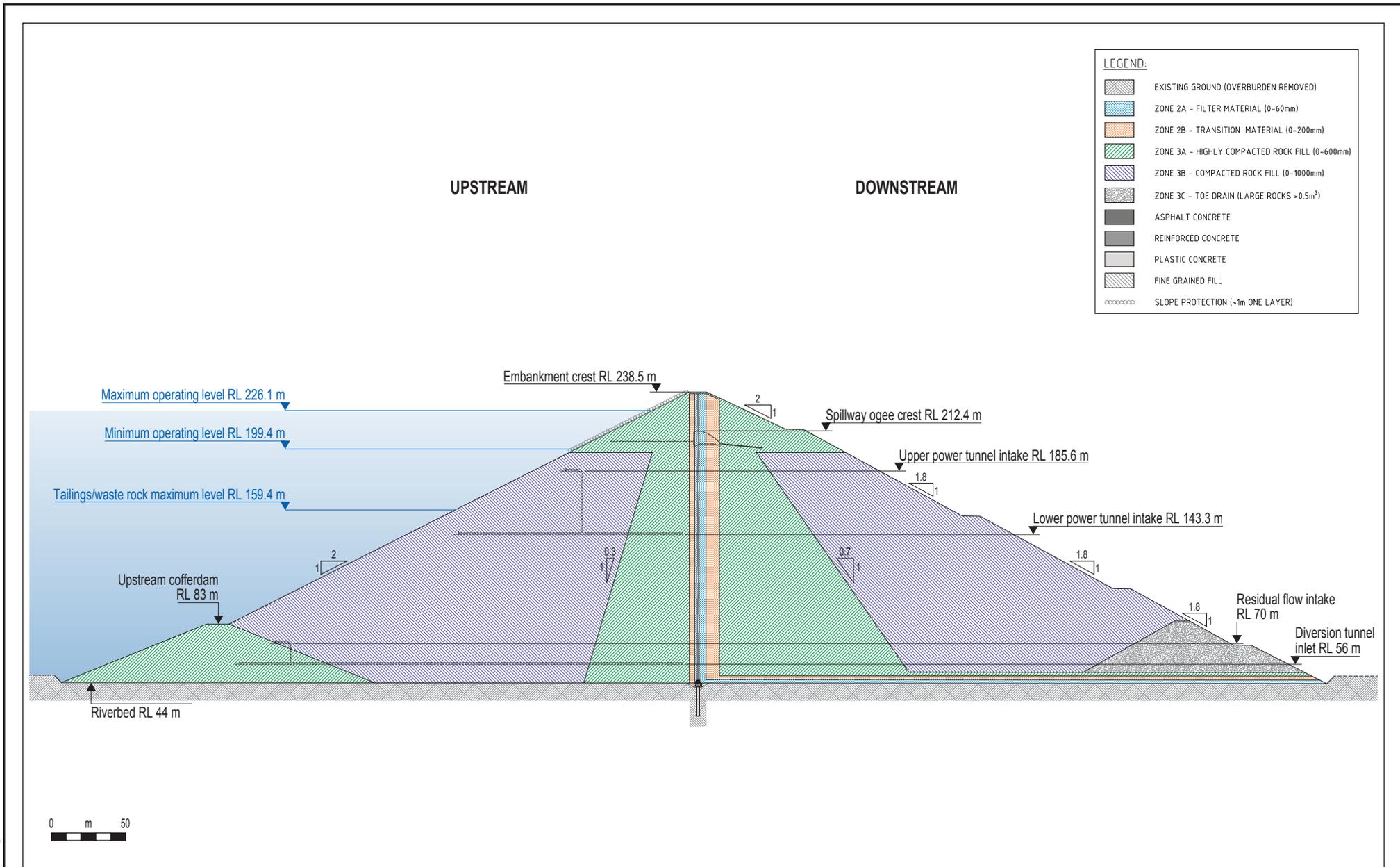
### **5.6.3 Spillway**

A gated spillway is included in the design. The spillway will comprise a nominally 30-m-long ogee crest on the east bank of the Frieda River with a reinforced concrete lined chute. A flip bucket and stilling basin at the toe of the chute will dissipate energy to reduce the erosive potential of water flowing down the spillway. A divider wall with four steel spillway radial gates will be installed into the spillway to permit partial and temporary closure of the spillway for maintenance activities.

A spillway discharge channel, if required, will reduce the erodibility of the river bed below the embankment and mitigate the risk of flooding of the powerhouse. The requirement for construction of this channel will be determined during detailed design.

### **5.6.4 Quarry**

A site for the quarry to provide construction materials for the embankment has been identified immediately south of the embankment, on the eastern side of the Frieda River. This quarry



**LEGEND:**

	EXISTING GROUND (OVERBURDEN REMOVED)
	ZONE 2A - FILTER MATERIAL (0-60mm)
	ZONE 2B - TRANSITION MATERIAL (0-200mm)
	ZONE 3A - HIGHLY COMPACTED ROCK FILL (0-600mm)
	ZONE 3B - COMPACTED ROCK FILL (0-1000mm)
	ZONE 3C - TOE DRAIN (LARGE ROCKS >0.5m <sup>3</sup> )
	ASPHALT CONCRETE
	REINFORCED CONCRETE
	PLASTIC CONCRETE
	FINE GRAINED FILL
	SLOPE PROTECTION (>1m ONE LAYER)

AI Reference: 11575\_11\_GRA/03.ai\_5

Source: Adapted from FRP-2-D-04-01-D-030-003, EMBANKMENT TYPICAL CROSS SECTION & DETAILS and FRP-2-D-00-01-D-030-010, CRITICAL LEVELS SECTION, SRK



Date: 24.09.2018  
 Project: 754-ENAUABTF11575B  
 File Name: 11575 11 F05.10 GRA

Frieda River Limited  
 Sepik Development Project



ISF embankment cross section schematic

Figure No: 5.10

provides a source of good quality dunite rock, which is within the reservoir, accessible in terms of topography and relatively close to the embankment. The depth of bedrock in the quarry area is generally shallow with less than 5 m of overburden. This quarry material is strong to very strong dunite rock. It is likely that within the quarry rock mass some localised zones of poorer quality, sheared/serpentinised or weathered rock may occur, but this is expected to represent only a small proportion of the dunite rock. Such materials are not appropriate for construction of the embankment and will be placed in the spoil dumps.

Rock sourced from the spillway excavation will also be used to construct the embankment.

### **5.6.5 Spoil Dump**

Spoil material from foundation excavations, quarry development and slope stabilisation will be placed in the upstream spoil dumps, together with sediment generated from the road slopes and other areas exposed during construction. Vegetation and organic material stripped from the site construction areas will also be stored within the spoil dumps.

The spoil dumps will be located upstream of the embankment on the north side of the Nena River and east side of the Frieda River, to facilitate construction on either side of the Frieda River prior to construction of the cofferdam. Any sediment generated will be carefully managed during construction to limit contamination of foundation works, including the cut-off wall, filter and transition layers, and to limit release of coarse sediment from the construction site. Stormwater and sediment management infrastructure including sediment ponds will be constructed for the spoil dumps.

### **5.6.6 Geotechnical Integrity of ISF**

PNG lies in an active seismic region, and several large faults are located in the FRHEP area. The potential for seismic activity was a key consideration in the design of the ISF to ensure the embankment is constructed to endure a maximum credible earthquake scenario.

Geotechnical investigation has included geomapping, geotechnical drilling investigations, material sampling and geotechnical laboratory testing activities. This work is subject to expert peer review by the TIRP.

Site geomapping activities have been performed over many phases of investigation; in 2010 to 2011 and more recently in 2017 to 2018. The information from mapping has been limited due to the steep terrain and thick forest, so drilling activities have provided the best understanding of ground conditions around the embankment and sources of construction material for the embankment.

Recent geotechnical drilling investigations in 2017 and 2018 included 40 drill holes near the embankment, spillway, tunnels and associated infrastructure, and nine drill holes for investigation of a quarry to provide embankment construction materials, totalling 4,650 m of drilling. This investigation was in addition to 27 holes drilled as part of an earlier site investigation in 2010 and 2011.

The site setting, as determined from geotechnical studies, can be summarised as:

- Bedrock of strong dunite rock is situated at shallow depth below surface (generally less than 10 m, but commonly less than 3 m) within the steep terrain of the embankment abutments. Overlying colluvial materials consist of thin soil cover and sometimes large boulders. Permeability of the dunite bedrock is generally low to moderate ( $10^{-9}$  to  $10^{-7}$  m/s), however

zones of high permeability are present locally as fault fracture zones. Curtain grouting has been planned to mitigate zones of high permeability adjacent to the embankment.

- The valley floor has a thick accumulation of alluvial and colluvial materials up to 70 m in thickness. The colluvial materials can be very coarse (including very large boulders), mainly clast supported, and with a cemented matrix presenting a weak rock strength of 2 to 10 MPa. The alluvial materials are often similarly cemented, however beneath the main river channel lie uncemented coarse alluvial materials (boulders, gravel and sand). Permeability in these materials is variable locally; generally, it can be considered moderate ( $10^{-7}$  m/s), but uncemented zones and zones of deteriorated matrix result in localised higher permeability. Therefore, a cut-off wall will be installed below the embankment within these materials.
- There is a zone of highly fractured rock on the left-hand abutment, mostly upstream of the embankment centreline, and extending above the level of the embankment crest. This material is comprised of deteriorated rock mass: rafts of intact fresh or weathered rock and layers of oxidised, deteriorated and possibly sheared soil-like materials. This material may already have undergone shearing and downhill creep and presents a significant landslide risk. It will be removed prior to embankment construction.

The investigations were designed to identify significant faults beneath the embankment and within the abutment area. Although several small faults of limited width have been encountered, the investigation has concluded that no large fault structure is present beneath the embankment. Two large regional faults are situated near the embankment site: the Frieda Fault is situated approximately 7 km to the south of the site, while the Saniap Fault is situated a kilometre to the north. Potential movement on these faults has been considered in the seismicity assessment for design of the embankment.

### **5.6.7 Waste Rock and Tailings Deposition**

The ISF is divided into three disposal areas or compartments for waste rock and tailings placement: the Nena compartment, the Ok Binai compartment and the Frieda compartment. Figure 5.11 shows the disposal areas within the ISF. A floating shear boom that extends the length of the waste rock/tailings boundary may be used to prevent interference between trash and/or waste disposal barges and the tailings deposition system area.

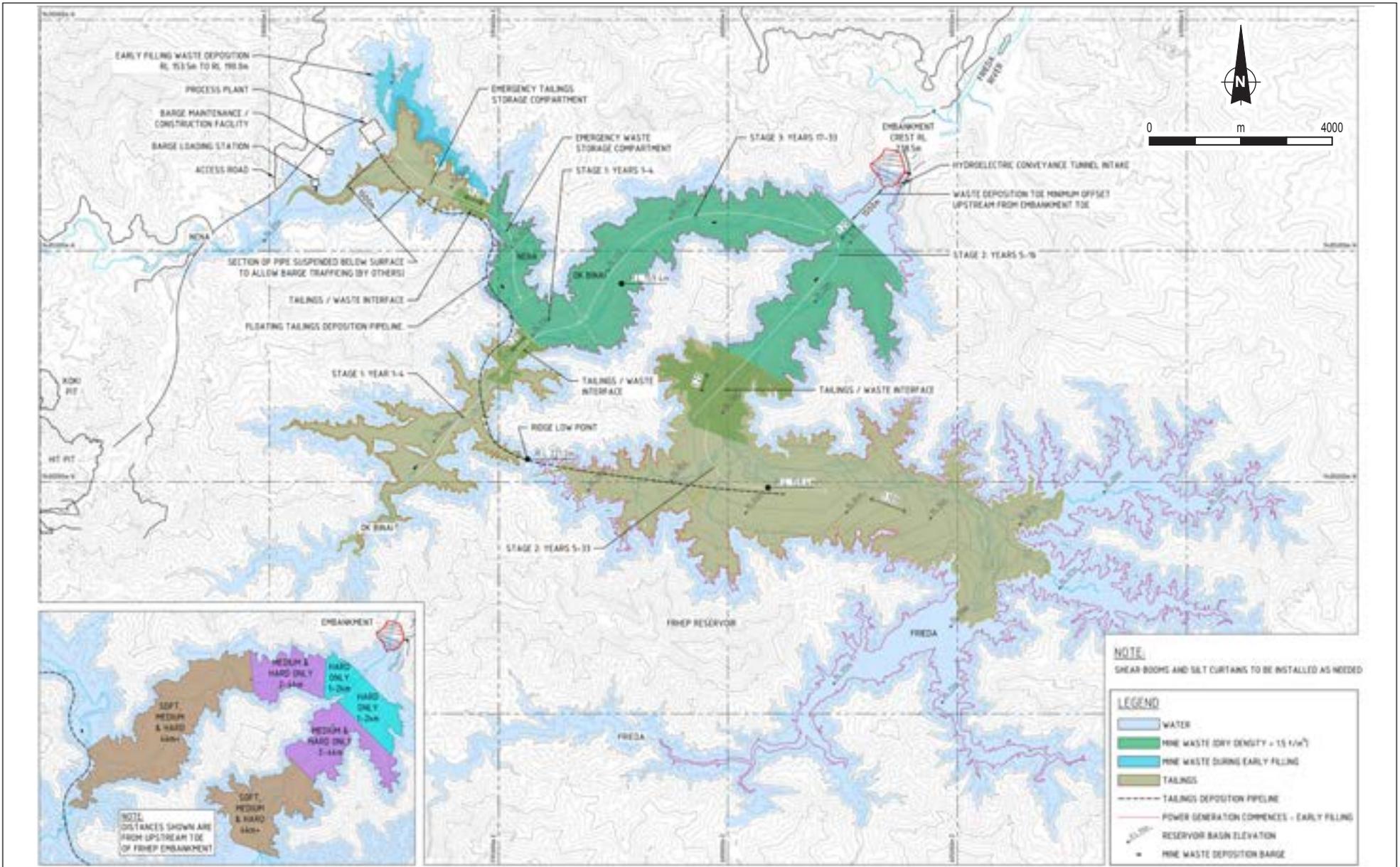
The waste rock and tailings deposition methods are described in Section 5.5.3.

### **5.6.8 Water Management**

#### **Operations**

The average river flow for the Frieda River is estimated to be 223 m<sup>3</sup>/s. There will be a need to continuously discharge water from the ISF to generate power and maintain a safe operating level because of the significant surplus of rainfall over evaporation, i.e., the volume of water falling as rain in the catchment of the ISF significantly exceeds the amount of water lost as evaporation from the surface of the ISF and infiltration into land. Therefore, the ISF has been designed as a 'flow-through' system.

Inflow water will be discharged to the Frieda River downstream of the ISF embankment. This will occur through a set of hydroelectric power intakes during operations and through the spillway during flood events. Prior to commissioning of the hydroelectric power facility, the environmental flow intake will allow for water discharge at 50 m<sup>3</sup>/s. There will be a period of two days when there will be no flow during the transition to the environmental flow intake and the full residual flow of



Source: FRP-2-D-00-01-D-030-002, WASTE ROCK & TAILINGS DEPOSITION LAYOUT (33 YEAR LOM), SRK



Date: 13.09.2018  
 Project: 754-ENAUABTF11575B  
 File Name: 11575\_11\_F05.12\_GRA

Frieda River Limited  
 Sepik Development Project



Waste rock and tailings deposition plan

Figure No: 5.11

50 m<sup>3</sup>/s will be restored after a total of five days assuming typical river flows. The hydroelectric power facility will maintain a minimum 50 m<sup>3</sup>/s discharge during the operating life of the facility.

There will be the capacity to increase flows from the ISF during filling using bypass valves if additional flows are required to allow barges to bring heavy construction components up the Frieda River. These valves also have the potential to supplement the spillway capacity.

The ISF will have freeboard to allow probable maximum flood (PMF) events to be discharged safely through the spillway without impinging on the embankment crest. The maximum operating water level will be RL 226 m and the maximum water level rise during PMF conditions will be RL 232 m. The minimum operating water level will be at RL 199 m. A displacement allowance of 7.8 m on the final embankment crest has been incorporated in the design to accommodate a seismic event.

### **Closure**

The ISF will remain in place after mine closure and the FRHEP may continue to generate power. When both the mine and the FRHEP 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 PMF and must be passed by the spillway even if the ISF is full of water or natural sediment.

Post closure there are expected to be infrequent occasions when the natural flow of the Frieda River will fall below 50 m<sup>3</sup>/s and under these circumstances the flow from the ISF will match the river flow.

The ISF is a flow-through facility and water downstream will need to meet water quality standards. The ISF has been designed so that more than 40 m of water will be maintained over the submerged waste rock and tailings 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. A schematic of the conceptual water management strategy during closure of the FRHEP is presented in Figure 5.12.

### **5.6.9 Sediment Management**

All mines constructed and operated in mountainous, high-rainfall environments such as at Frieda River generate fugitive sediment, particularly during the construction phase. The volume of sediment generated during operation and reporting to the downstream environment is typically orders of magnitude lower than during construction.

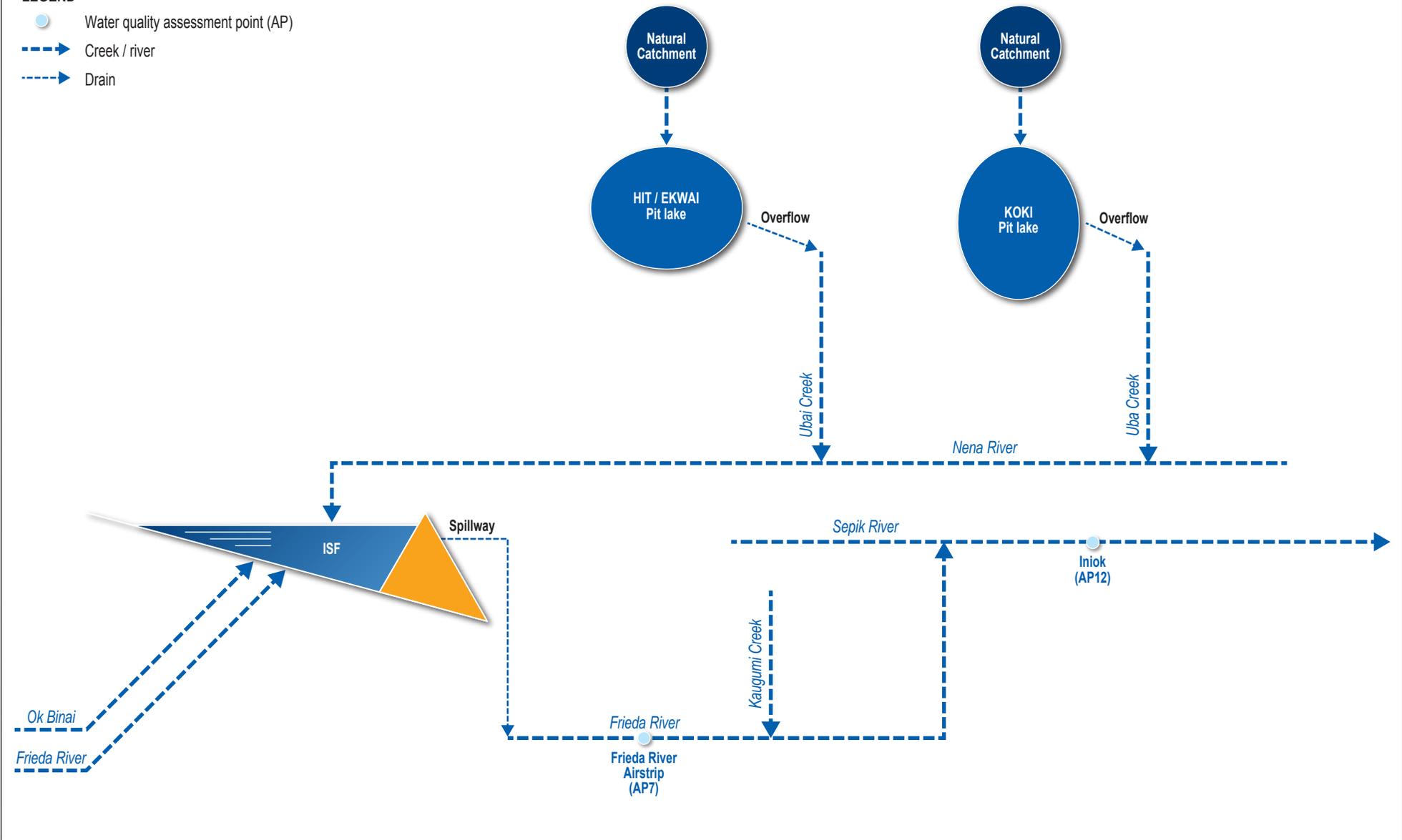
Because the ISF is located downstream of the major areas of earthworks for the mine such as the open-pit, process plant and spoil dumps, it will act as the critical sediment management facility for the mine site, allowing sediment to settle-out prior to water discharge via a power intake tunnel or over the spillway. This will have consequent benefits for the downstream environment.

Sediment management measures include:

- Jute matting (or similar) will be installed where practicable to provide temporary erosion protection to excavated surfaces, with predicted sediment reduction of approximately 85 to 95% depending on the slope length and angle. Shotcrete and mesh may be used on permanent and semi-permanent slopes.
- Diversion channels will be installed above the roads and foundation cuts in order to prevent runoff entering the worksite. This will reduce erosion, pumping requirements and sediment pond requirements.

**LEGEND**

-  Water quality assessment point (AP)
-  Creek / river
-  Drain



AI Reference: 11575\_11\_GRA010.a1\_6

Source: FRL, 2016



Date:  
24.09.2018  
Project:  
754-ENAUABTF11575B  
File Name:  
11575\_11\_F05.12\_GRA

Frieda River Limited  
Sepik Development Project



Conceptual mine water balance  
schematic - FRHEP closure

Figure No:  
**5.12**

- Two spoil dumps have been sized and designed upstream of the embankment to create adequate storage for spoil material excavated from construction of the embankment and overburden from the quarry. The spoil dumps have been sized to accommodate any sediment captured during construction of the ISF.
- Multiple sediment ponds have been designed at the toe of the spoil dumps to allow for the settling of sediment and for any potential treatment before water is released to the river system. The sediment ponds have been designed to store the 1:10-year, 24-hour storm, plus a 40% allowance for sediment build-up, while pond spillways have been designed to pass the 1:50 year average recurrence interval peak flow. The sediment ponds will be developed progressively as spoil and waste rock dump areas increase.
- Clean surface water (i.e., water that runs off undisturbed land, jute matting, shotcrete or rock fill) will be diverted directly into the river system via channels, culverts and pumps. Contact surface water (i.e., water in contact with unprotected excavated soil) will be diverted and transferred to sediment ponds before discharge to the river system.

It is estimated around 99% of sediment inflow to the ISF, including natural and Project induced sediment load, tailings and waste rock will be retained within this storage and not transported further downstream. The sediment load discharged from the ISF over a 39 year period from commencement of its operation to four years post closure of the FRCGP is 29 Mt compared to an estimate of 66 Mt under existing conditions.

### **5.6.10 Limnology Investigations**

The embankment will impound a waterbody of approximately 7,000 gigalitres (GL) at minimum operating level of RL 199 m extending to more than 10,500 GL at probable maximum flood level of RL 232 m. The reservoir will inundate three major river courses that form the primary branches of the ISF: the Nena which flows from the west of the embankment; the Ok Binai, which flows from the south-west and converges mid-way along the Nena branch; and the Niar (Upper Frieda), which carries converged flow from numerous dendritic sub-branches that flow from the south towards the embankment.

As discussed in Section 5.5.3, waste rock and tailings will be deposited up to RL 159 m in the inundated river valleys.

Modelling was undertaken by Hydronumerics (Appendix 2b) to provide a semi-quantitative assessment of the hydrodynamics, sediment transport and basic water quality aspects of dissolved oxygen, nutrients, primary production and organic matter within the ISF.

The key risks identified included:

- High organic matter and biological oxygen demand, and low oxygen concentrations.
- Potential for generation of hydrogen sulphide in the anoxic hypolimnetic (lower layer) region of the lake.
- Nutrient enrichment from the decay of flooded vegetation and soils.
- Release of tailings or fine waste rock into the water column during the deposition process.
- Scouring of fine tailings from bottom storage during natural water inflows.
- Release of metals from waste rock and tailings.

The current ISF design aims to minimise the risks associated with the release of tailings as suspended solids during deposition by using a tremie diffuser.

The modelling demonstrated that the TSS contribution to the powerhouse intake water from barge dumping of soft waste rock (with a 10% size fraction less than 40 µm) was dependent on the distance and frequency of deposition. The larger particles settle to a level below the intake tunnel prior to its entrance whereas the finer particles may be transported to the intake. A deposition distance of greater than 1,000 m from the embankment has been adopted to minimise TSS transport to the hydropower intake. This prolongs the life of the hydropower infrastructure while also reducing downstream impacts.

Deposited particles may be resuspended if there is sufficient bottom shear to overcome the critical shear required for suspension. This typically takes place during high flow events that scour the bottom of the reservoir near the headwaters. The Project deposition strategy reduces the risk of scouring by placing tailings away from the headwaters of the large tributaries.

### **5.6.11 ISF Stewardship**

#### **Overview**

The design criteria for the ISF is based on credible extreme rainfall and seismic events that have a low probability of occurring. The design will be further supported by appropriate levels of stewardship through construction, operations and closure.

Stewardship relates to the company's behaviours in managing the facility. FRL's owner, PanAust, has well-established stewardship programs for its operations in Laos where, at the Phu Kham Operation, the tailing storage facility embankment is planned to reach a height of 175 m, similar to that for the Sepik Development Project. The stewardship activities in place at the Phu Kham Operation are:

- A commitment from the company at the highest level to ensure construction and operating procedures for the facility are followed.
- Appointment of an independent tailings review panel (the TIRP) reporting directly to PanAust's Managing Director on material risks to the facilities. The TIRP undertakes annual visits to site.
- Defined processes and procedures which are communicated and followed.
- A principal tailings engineer based in the corporate office to provide overview and quality assurance of design and construction activities.
- An Engineer of Record is responsible for the design.
- An independent expert consultant is engaged to complete the designs.
- Multiple systems are used for monitoring seepage and embankment and these are audited.
- An on-site laboratory systematically provides results for quality control and quality assurance of construction materials.
- A mine closure plan contemplates the key features at closure.
- A risk based review is completed annually.
- Dam safety audits are completed by a third party.

The FRHEP will adopt a similar stewardship program to what is established at PanAust's existing operations with additional focus on water management. The TIRP has recommended that:

- It is essential to apply the highest level of stewardship to the design, construction and operation of the ISF, including the appointment of a well-qualified and experienced design team and a well-qualified and experienced Engineer of Record.
- Provision be made for independent review of the design, construction and operation of the ISF by world class experts in the various critical disciplines, including geotechnical engineering, tailings management, seismicity and dynamic design analyses, hydrology, hydraulic design and dam and tunnel construction.
- An operating protocol be developed to manage the interaction between, and the objectives of, the dam construction team, the waste rock and tailings disposal teams and the power generation team.
- The management team for the ISF must have the appropriate level of experience.
- The monitoring, maintenance and oversight, which will be needed both during operations and after closure, is included in the stewardship plans.

FRL has addressed these recommendations and commenced an ISF stewardship program during the design of the ISF and independent expert review by the TIRP. The FRHEP stewardship program will continue through the life of the ISF and comprises:

- A dam safety program as described by the ICOLD and most of its associated national organisations, including ANCOLD and the Canadian Dams Association.
- A corporate governance and reporting structure.

Critical elements of the corporate governance and reporting will include:

- Specific accountability for embankment construction, operation and safety at the Board and senior management and executive levels.
- Training at all levels, including senior management and executive management, to ensure a full understanding that dam safety is fundamental to the business.
- Executive and senior management commitment to ensuring that a dam safety culture is established, monitored and continuously improved.
- Clear management accountabilities, reporting relationships and business systems that make dam safety part of the normal work flow and reward systems.
- At the corporate and site level, a clear understanding of the scenarios that exist for post-mining operation of the hydroelectric power facility; systems for ensuring long term management of dam safety after the mine closes need to be in place, together with a clear understanding of the risks involved.

External parties will also play an important role in ISF stewardship, particularly the PNG Government. FRL hosted a technical workshop with CEPA and MRA in Port Moresby (8 August 2018) to introduce the design of the ISF. In addition, FRL, Coffey and the TIRP held technical workshops with CEPA and MRA in Port Moresby on 28 August 2018 to present and further explain the ISF design and to answer any technical questions.

Routine Frieda and Sepik river awareness engagement campaigns have introduced the concept of the ISF to downstream villages. Chapter 4 provides details of this consultation.

### **Dam Break Analysis**

Commonly known as a 'dam break' analysis, SRK and FRL have modelled a theoretical dam break scenario to inform the design of the ISF and to ensure that appropriate factors of safety have been incorporated into the design. The analysis illustrates the consequence in the unlikely event of a dam wall failure.

The ISF dam structure is classified in the highest consequence category (ICOLD, ANCOLD), because of the size of the downstream population at risk. The dam break modelling was used to simulate a very low probability failure event to assess the risk and the development of suitable emergency response plans. The analysis indicates that there would be significant water level rises in the Frieda River below the ISF and Sepik River further downstream. The potential impacts would decrease with distance downstream from the ISF.

Significant environmental impact would be expected following a dam break due to the instantaneous flooding, but also the long-term effect of contamination due to the release of the tailings solids and waste rock stored in the ISF.

The key elements of the emergency response, further outlined in Chapter 10, include:

- Early warning surveillance monitoring of the ISF embankment.
- Alert and communication system and procedures for potentially affected communities.
- Evacuation plan for the site and potentially affected communities.
- Emergency support plan for essential services to affected communities.

### **5.6.12 Hydroelectric Power Generation**

The hydroelectric power generation facility will be located immediately downstream of the main embankment adjacent to the Frieda River. The hydroelectric power facility will be operational in the first year of operation to supply power for commissioning of the FRCGP.

The hydroelectric power facility will comprise:

- An intake structure located adjacent to the embankment, consisting of low and high intakes. These will be located to suit the rising water levels during filling of the reservoir. The lower intake structure will be abandoned and sealed before it is submerged. The high-level intake to both tunnels will be fitted with an emergency close gate (wheel gate), maintenance gate, bar screen, automated screen cleaner and associated crane and electrical equipment. The low-level intake will be in use for a short period of time and will be similar to the high-level intake, except there will only be one inlet and no screen cleaner.
- Tunnels connected to a buried penstock that delivers water to either the power station generating units or the four power station bypass valves.
- A conveyance system consisting of two fully concrete-lined pressure tunnels, connecting the intakes to the outlet portal near the powerhouse. These twin tunnels (nominally 7 m in diameter and 526 m in length to the surge chamber) will be constructed with a horseshoe shape cross section.
- Concrete-lined surge chamber (12 m internal diameter) connecting the waterway to the open air above the embankment crest at level RL 255 m, one on each conveyance system.

- Twin steel lined tunnels (7 m internal diameter and 463 m in length) connecting the surge chamber to the downstream portal.
- Steel penstocks (7 m internal diameter and 165 m in length) connecting the tunnels to the powerhouse and an additional 80 m to the bypass valves.
- Reinforced concrete channel structure tailrace to direct the discharge water downstream of the powerhouse building.
- Powerhouse consisting predominantly of reinforced concrete (190 m in length, 34 m in width and 47 m in height, with 33 m above the normal river level). The powerhouse will contain eight 68 MW and two 19 MW Francis turbines, generators, associated equipment and workshop-type facilities.
- Powerhouse substation consisting of eight 80 MVA transformers, two 22 MVA transformers and gas insulated 132 kV switchgear. There will be a load bank allowing the units to be commissioned prior to the FRCGP being commissioned.
- Several access roads to connect the intakes, surge shaft and powerhouse to the other Project site roads.

The layout of the hydroelectric power facility is shown in Figure 5.13.

### **5.6.13 Ancillary Infrastructure**

The FRHEP will be constructed using both riverine logistics along the Sepik and Frieda rivers and road logistics from Vanimo. Road transport will predominantly be used during operations; riverine transport may also be used on an as required basis. A port will be constructed on the Frieda River to allow for riverine transport.

#### **Frieda River Port**

The Frieda River Port will be a concrete structure and will be used for importing construction materials. The port will also be used during operations on an as required basis.

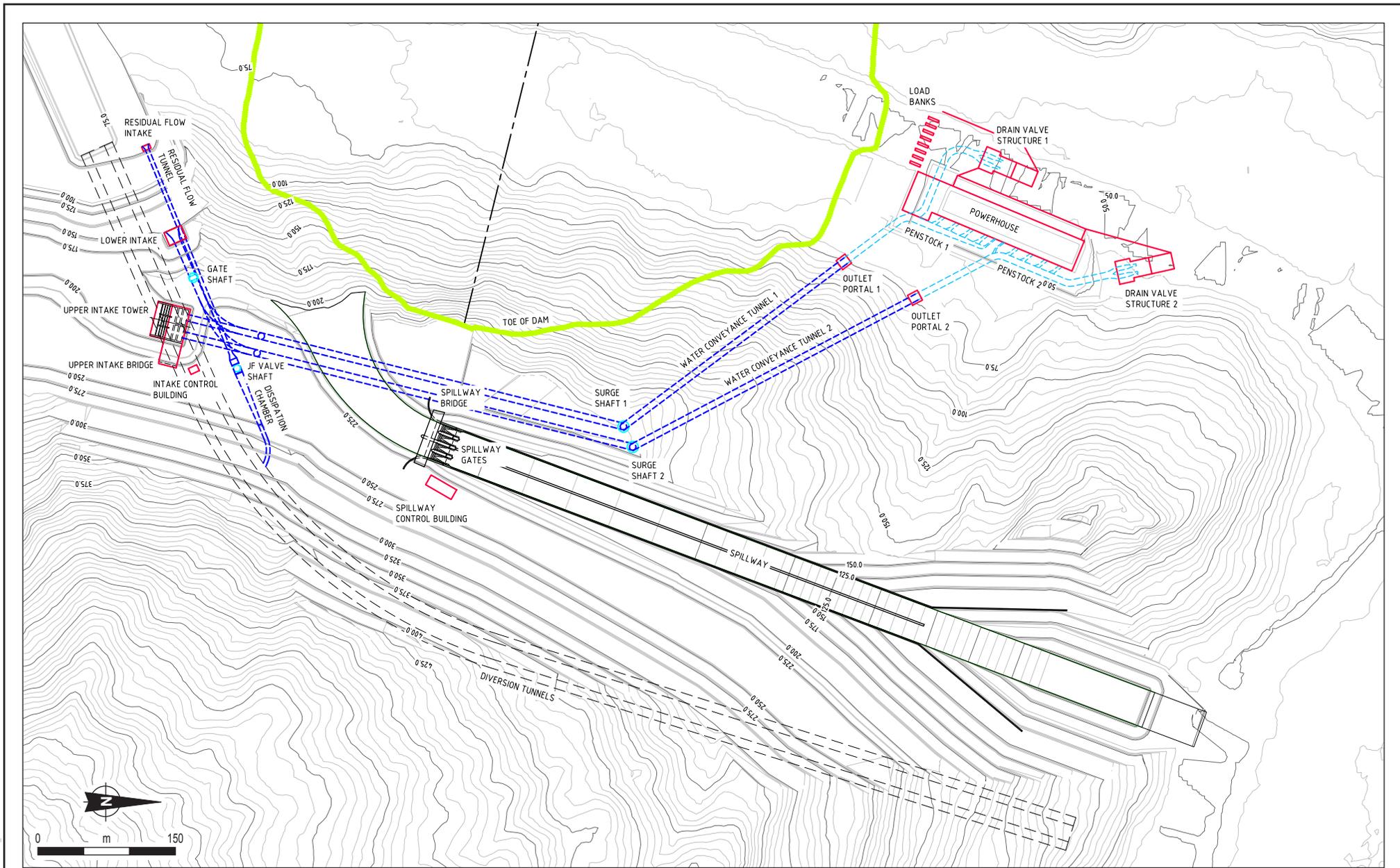
The Frieda River Port will be a fenced facility and will facilitate unloading of break-bulk and containerised cargoes from landing craft, transfer of heavy equipment from barges onto a low loader, and mooring points for tugboats. The port will have on-site diesel power generation.

#### **Access Roads**

There will be a 40-km-long unsealed 7.5-m-wide dual-lane access road (FRHEP access road) from the Frieda River Port to the powerhouse and ISF. There will also be a 33-km-long unsealed 7.5-m-wide dual-lane road (link road) from the powerhouse to the process plant. The design criteria for these roads will accommodate all loads during construction and operations.

#### **Frieda River Airstrip**

The existing Frieda River airstrip (Plate 5.4) is used to support FRL exploration activity. It will be improved, extended and used as the primary airstrip until the Green River Airport upgrade is completed. The Frieda River airstrip will be used for some personnel transport (e.g., management personnel on shorter rosters and some Zone 2 employees) and emergency purposes during both construction and operations. The upgraded airstrip will service Code 1 (18 seat) aircraft and will include a 120-m-long by 60-m-wide runway strip extension, increasing the overall length to 760 m.



AI Reference: 11575\_11\_GRA050.a1\_1

Source: 80510050-G001 FRIEDA RIVER HYDROELECTRIC PROJECT SCHEME LAYOUT PLAN.pdf, SRK



Date: 17.08.2018  
 Project: 754-ENAUABTF11575B  
 File Name: 11575\_11\_F05.13\_GRA

Frieda River Limited  
 Sepik Development Project



Hydroelectric power facility layout

Figure No: 5.13

## **Accommodation**

FRHEP construction accommodation will include a combination of building and room types and will house up to 3,270 personnel. Following construction, several buildings will be refurbished and used for accommodation during operations, with approximately 420 beds.

## **Site Support Facilities**

FRHEP site support facilities will include, but not be limited to:

- Administration building.
- Emergency response centre.
- Medical centre.
- Administration building and control room.
- Workshop.
- Warehouse.

### **5.6.14 Closure Strategy**

After removal of the spillway gates, the ISF will remain as a permanent water body to limit contact of PAF mine waste material with oxygen and the potential for AMD. At the time of closure the long-term stewardship roles and responsibilities for the ISF will have been agreed with relevant stakeholders. Further closure details for the FRHEP are provided in the FRHEP Conceptual Closure Plan (Appendix 3b).

## **5.7 Sepik Infrastructure Project**

The SIP comprises upgrade of the existing port located at Vanimo, upgrade of the Vanimo to Green River Road, construction of a public road from Green River to Hotmin and an upgraded Green River Airport. A road from Hotmin to Telefomin may also be constructed, but this is not required to support the FRCGP or FRHEP and is not part of this EIS.

### **5.7.1 Vanimo Ocean Port**

The existing port at Vanimo on the eastern shoreline of Dakriro Bay (Plate 5.5) will be upgraded through the SIP to support the FRCGP and other regional users. The upgraded port will be developed as a multi-user facility suitable for international vessels up to Handymax size and will cater for export of copper concentrate and import of freight and fuel. Other products will be able to be exported by other users.

The upgraded Vanimo Ocean Port will have two international berths in the initial development:

- Outbound copper concentrate berth (dedicated for FRCGP).
- General international freight berth (suitable for fuel and freight vessels).

Upgrade of the Vanimo Ocean Port will require reclamation of approximately 3.4 ha of the bay adjacent to the existing port. The port development will provide an apron for intended users to construct dedicated and shared facilities. The marine structures will be expandable to include additional berths as the region develops and demand increases. Due to space restrictions at the port apron, some facilities to support the FRCGP will be located at an infrastructure area within the township of Vanimo (see Section 5.5.9).

The following multi-user facilities will be developed at the Vanimo Ocean Port:

- General international berth including:

- Fuel pipeline to transfer point.
- Lines and work boat.
- Port office building including a maintenance workshop.
- Container laydown including:
  - Container wash.
  - Customs/duty quarantine laydown area.
  - Hazardous stores.
  - Truck parking area.
- Fuel storage.

The general use facilities at the port will source power and water from town supply.

### **General Cargo Wharf**

The general cargo wharf has been designed for international tanker and cargo vessels up to Handymax size. The wharf will be constructed using prefabricated concrete slabs to form a continuous concrete deck supported by piled foundations. Two mobile harbour cranes will operate at the port to manage the handling of empty and full containers to the container laydown area and vice-versa. Each mobile harbour crane will have a capacity of 180 t to allow for the lifting and handling of 40 foot containers with an outreach of 25 m.

The wharf will be fitted with a pipeline to allow for the offloading of diesel which will be pumped to the Vanimo Infrastructure Area.

### **Port Office Building**

The port office building will provide office workspace for the port operator personnel and quarantine functions.

### **Container Laydown**

The container laydown at the Vanimo Ocean Port has been designed to cater for storage of full and empty standard and refrigerated containers for other port users and temporary storage while vessels are being loaded or unloaded.

The container laydown area on the port apron will be limited to 1 ha total storage area including container wash, customs, duty, quarantine and hazardous stores.

The container laydown area will include provision of space for parking of mobile equipment servicing the Vanimo Ocean Port such as container handlers, forklifts and shuttle trucks.

### **Diesel Tank Farm**

The existing diesel tank farm at the port will be upgraded to cater for the predicted increased demand for diesel in the region and the existing footprint for diesel will be increased to 400 m<sup>2</sup>. This upgrade will not support the FRCGP, which will receive separate bulk diesel parcels. Tanks will be located on a concrete pad foundation with a concrete containment bund. Refuelling facilities located adjacent to the tank farm will be included within the containment bund.

## **5.7.2 Regional Road**

The existing public road from Vanimo to Green River (Plate 5.6) will be upgraded, and a new road constructed from Green River to Hotmin (and on to the mine site, but this will not be available for

public use). The road will allow for public transport, commercial ventures and access to new markets. The existing public road is maintained in good condition from Vanimo to Kwomtari, but its condition degenerates rapidly after this and sections between Kwomtari and Green River are at times impassable.

The 7.5 m-wide all-weather unsealed gravelled access road will lie within a corridor approximately 40 m-wide and will be built to allow standard road registered axle loadings. The design speed of the road will be 60 km/h but will reduce to 25 km/h in some locations due to tight horizontal curves and steep vertical grades in mountainous terrain. The road will be two-way and suitable for wet weather use.

Road construction materials will be sourced from existing and new quarries to be developed adjacent to the road corridor. Existing quarry sources between Vanimo and Green River will be used for the upgrade works and to source pavement and borrow material to build south to the Sepik River. General and select fill will be sourced from the deeper cuttings along the road alignment and hauled to the fill locations.

Construction of the regional road will require approximately 19 Mm<sup>3</sup> of cut and approximately 4 Mm<sup>3</sup> of fill. The road will have a maximum grade of 12% to allow heavy lift trailers carrying up to 220 t to be pulled by prime movers.

The mountainous terrain sections will be constructed in cut (Figure 5.14). Most of the excess spoil will be sidecast in close proximity to the road alignment. Areas where sidecasting is not preferred are those where the sidecast volumes will impact with the natural flow of drainage channels, creeks and rivers. In steep terrain that is not suitable for long term stability of large volumes of material, excess spoil will be hauled a short distance to a suitable location where the material will be co-located with other sidecast material.

The Sepik River floodplain section of the road will be constructed as a compacted rock-fill embankment up to three metres high (Figure 5.15). In this section, drainage structures will be constructed to allow water movement to mimic the natural hydrological regime. Concrete floodway structures will be constructed in some segments to allow floodwaters to flow over the road without causing damage.

A total of five major bridge river crossings will be required along the regional road. This includes one crossing over the Sepik River and four major bridges greater than 100 m in length across other regional rivers. In addition, 16 minor bridges will be required to cross small creeks. The Sepik River bridge is discussed in detail below; other bridges will be steel box girder bridges with spans ranging from approximately 20 m up to 100 m in length. Figure 5.16 shows a typical bridge crossing.

Ongoing maintenance requirements for the regional road will include the following:

- Gravel re-sheeting and pavement repairs.
- Drain desilting/unblocking/debris removal.
- Scour repairs.
- Top-up of embankments and pavement where settlement occurs.
- Road furniture repair and replacement.
- Grass cutting to road verges.
- Grading and rolling of road surface.
- Clearing landslips from the roadway and drains.
- Vegetation clearing for visibility.



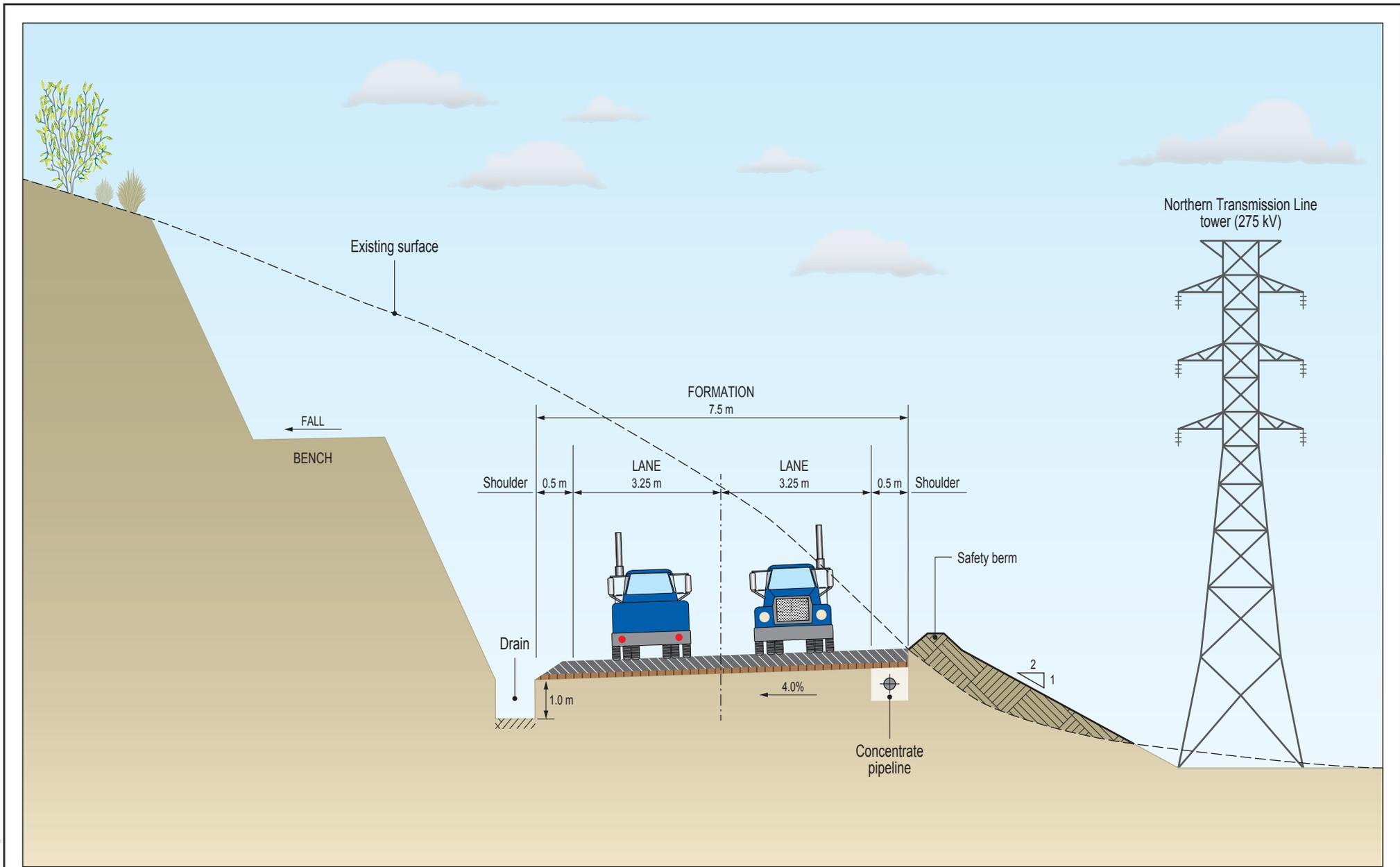
**Plate 5.4**  
Existing Frieda River airstrip



**Plate 5.5**  
Existing Port of Vanimo



**Plate 5.6**  
Existing Vanimo to Green River Road,  
near Green River



AI Reference: 11575\_11\_GRA07.a\_4

Source: FRL, 2018.  
Note: Not to scale. Indicative only.



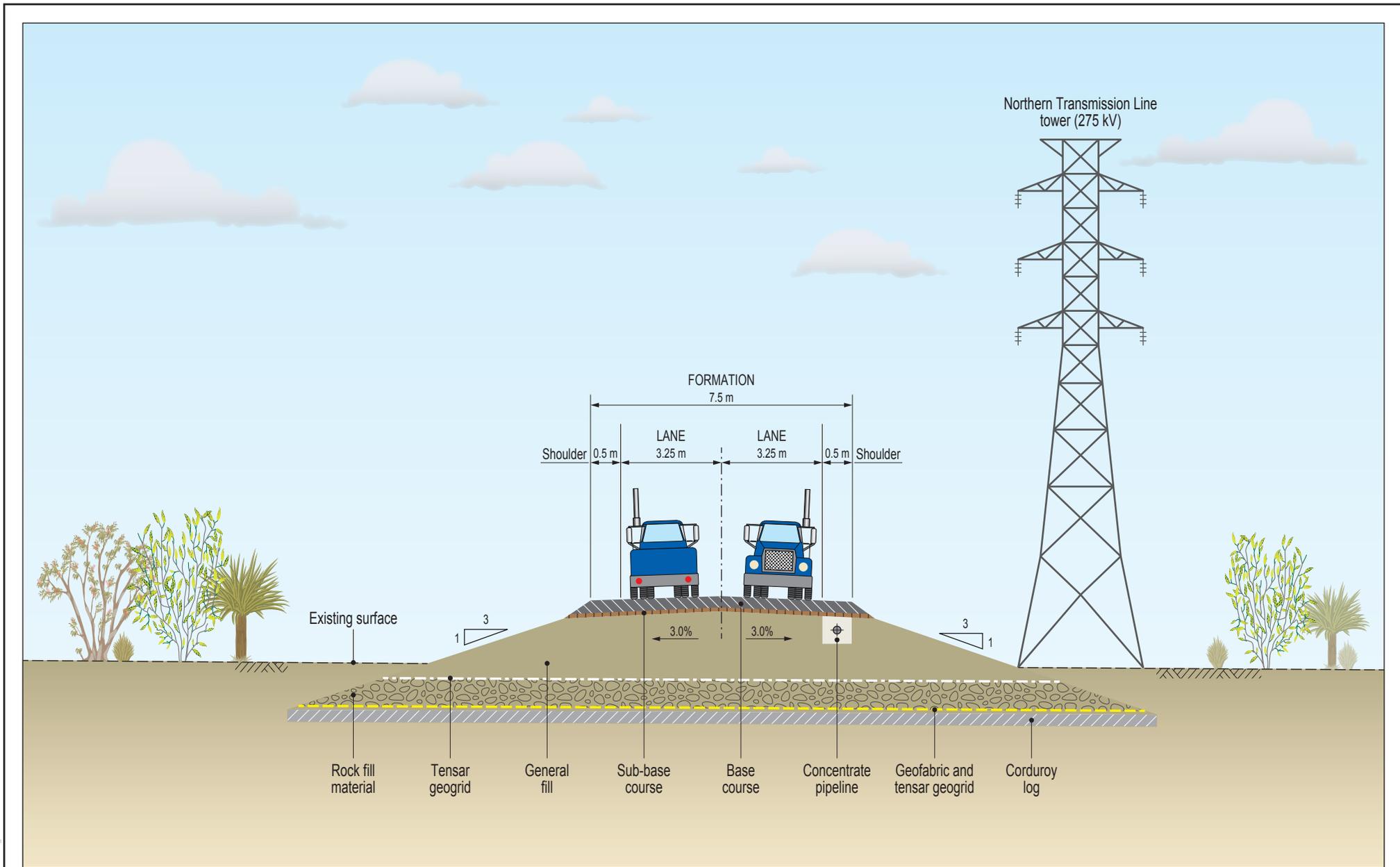
Date:  
13.09.2018  
Project:  
754-ENAUABTF11575B  
File Name:  
11575\_11\_F05.14\_GRA

Frieda River Limited  
Sepik Development Project



Typical road section through mountainous terrain

Figure No:  
**5.14**



AI Reference: 11575\_11\_GRA016.a1\_4

Source: FRL, 2018.  
Note: Not to scale. Indicative only.



Date: 13.09.2018  
Project: 754-ENAUABTF11575B  
File Name: 11575\_11\_F05.15\_GRA

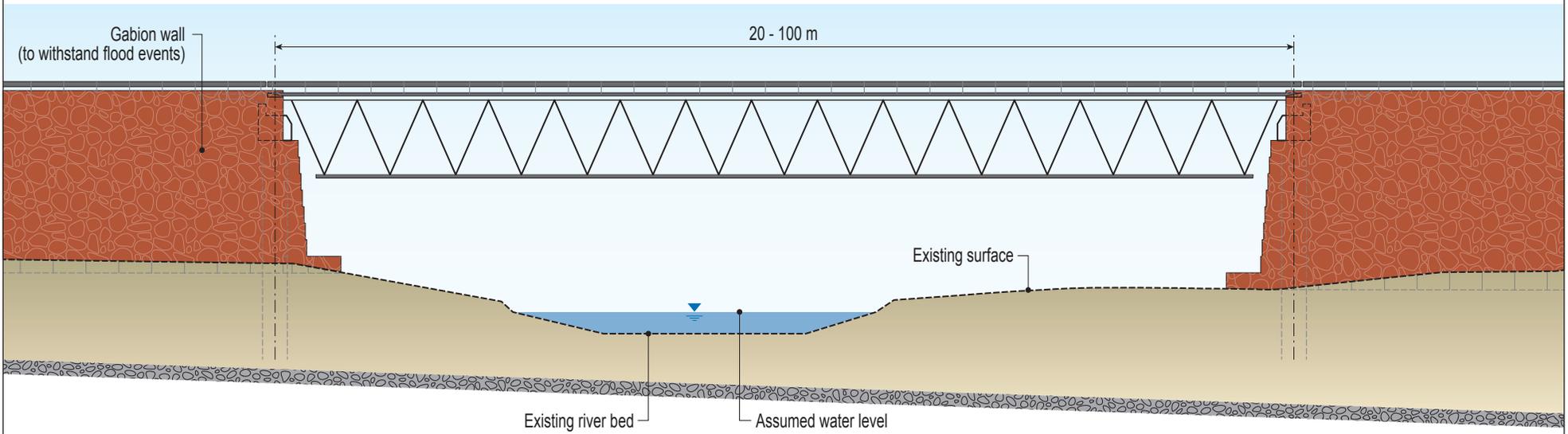
Frieda River Limited  
Sepik Development Project



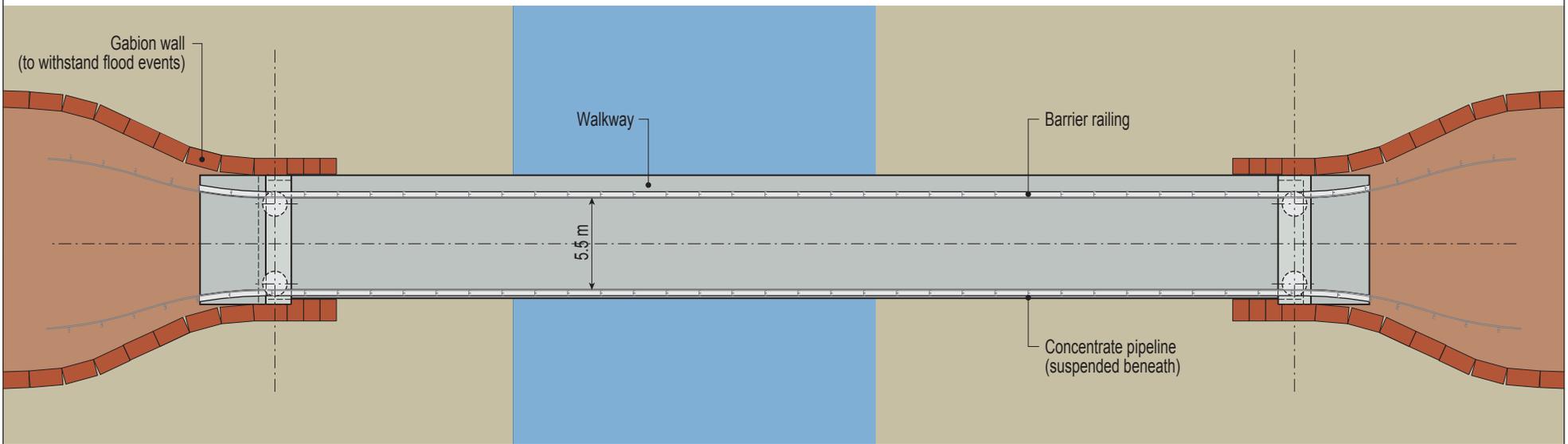
Typical road section through Sepik River floodplain

Figure No: 5.15

### ELEVATION



### PLAN



AI Reference: 11575\_11\_GRA018.a1\_3

Source: FRL, 2018.  
Note: Not to scale. Indicative only.



Date: 16.08.2018  
Project: 754-ENAUABTF11575B  
File Name: 11575\_11\_F05.16\_GRA

Frieda River Limited  
Sepik Development Project



Typical access road bridge crossing

Figure No: 5.16

- Replacement/repair of deteriorated/damaged pipes.
- Re-instating road embankments.

Maintenance of the public road from Vanimo to Hotmin will be undertaken by contractors who will likely be engaged through co-operative business ventures. The FRCGP will not maintain the road; however, provision has been made for road maintenance supervisors and civil engineers to ensure the standard of the road meets the specification required for mine traffic, particularly relating to safety.

### **Sepik River Bridge**

A new 350 m bridge will be built at the Sepik River crossing. The bridge will be dual lane with traffic safety barriers and a pedestrian walkway, as shown in Figure 5.17.

In the absence of detailed PNG standards for bridge design, the Sepik River bridge has been designed primarily in accordance with Australian Standards including the Bridge Design Standard AS5100.

The bridge will be approximately 25 m above the river bed to allow for the frequent flooding of the Sepik River that occurs during wet seasons. Rock embankment protection is included in the design to protect the abutments and piers from river scour.

A cross river vehicle ferry service will be required for construction.

River traffic will be able to continue to navigate the river during construction and once the bridge is completed. The bridge height will allow for tugboats and cargo barges up to 10 m in height to be able to pass during high water levels.

### **5.7.3 Green River Airport**

The existing airstrip at Green River is located 150 km from the mine. It is currently a well-formed but simple airstrip with infrequent use. It will be upgraded to an international airport that will cater for larger aircraft (up to Lockheed C-130) and be available for commercial domestic use.

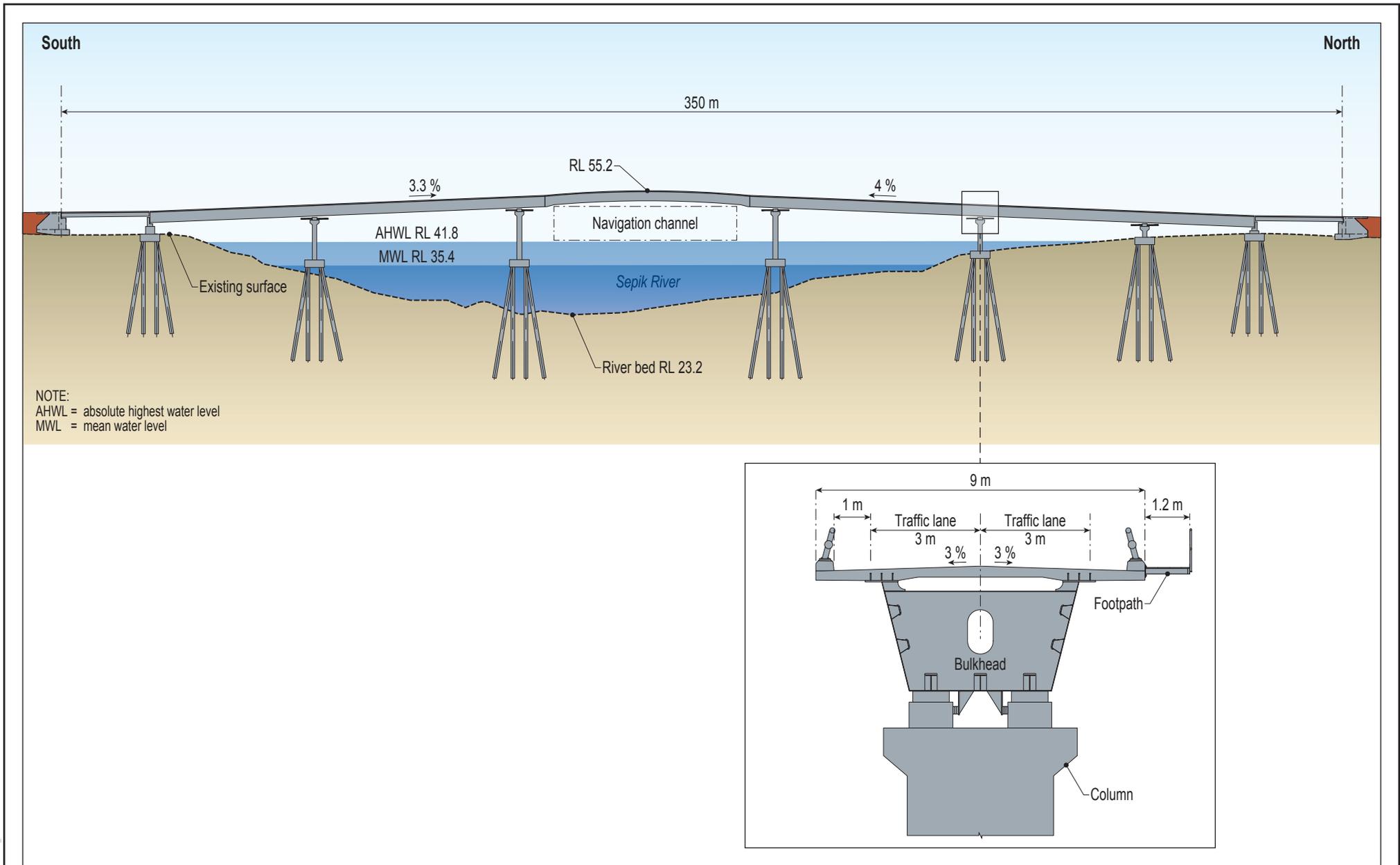
The new facilities will include a terminal with the capacity for 80 passengers, baggage handling facilities, immigration and customs, freight handling and storage facilities.

Airport design will comply with Civil Aviation Safety Authority of PNG requirements with respect to navigation equipment, security, maintenance and refuelling.

During operations, there will be a requirement to operate up to seven flights using Twin Otter aircraft each week to regional airstrips and fourteen 50 seater flights to commercial airport hubs (e.g., Wewak, Mount Hagen and Port Moresby) each week. The numbers and frequencies will be planned in accordance with the demographics for operations personnel.

The proposed facilities at the airport will also include:

- Offices and other rooms for briefings, inductions, handovers and general operations.
- Vehicle parking.
- Maintenance building.
- Fire and rescue area.
- Refuelling facility.



AI Reference: 11575\_11\_GRA011a1\_4

Source: FRP-2-K-02-01-L-030-001 & FRP-2-K-02-01-L-030-002



Date:  
16.08.2018  
Project:  
754-ENAUABTF11575B  
File Name:  
11575\_11\_F05.17\_GRA

Frieda River Limited  
Sepik Development Project



Sepik River bridge

Figure No:  
**5.17**

#### **5.7.4 Temporary River Ports**

In addition to the Frieda River Port, two other temporary river ports will be required for transport of freight during construction:

- May River Port, located on the May River approximately 15 km north of Hotmin. A temporary access road will be constructed from the port to Hotmin. This temporary port is required to mobilise equipment and supplies for expedited road construction.
- Upper Sepik River Port, located on the Sepik River at the location of the Sepik River bridge. This temporary port will allow freight to be barged from Green River to work sites prior to completion of the main access route.

The temporary river ports will be fully fenced concrete structures and will facilitate loading or unloading of break-bulk and containerised cargoes from landing craft, transfer of heavy equipment from barges onto a low loader, and mooring points for tugboats. The ports will have on-site diesel power generation.

### **5.8 Sepik Power Grid Project**

The FRHEP will generate power in excess of that required by the FRCGP and provides an opportunity to supply power to communities along the infrastructure corridor, to industries such as agriculture, fisheries, food and timber processing, mining and manufacturing, and for export to Indonesia. This EIS assesses Stage 1 of the SPGP which involves the construction of the Northern Transmission Line and the SWER network.

The Northern Transmission Line will be a new 370-km-long 275 kV line from the FRHEP to the Indonesian border, via Vanimo. The Northern Transmission Line will be located within the infrastructure corridor and will provide power for the offsite FRCGP facilities at Green River and Vanimo. The transmission line will follow the existing Vanimo-Jayapura Highway from Vanimo to the Indonesian border.

A SWER line will distribute power along the transmission line alignment. Overhead SWER networks are a cost-effective way to provide small power loads across a widely-dispersed area, making this suitable for the sparsely populated region along the infrastructure corridor. There will be three 19.1 kV SWER networks originating from the FRCGP, Green River and Vanimo substations. The SWER networks will provide the opportunity for a third-party power provider to connect and sell electricity to communities along the infrastructure corridor.

The domestic loads predicted along the infrastructure corridor within Hotmin, Green River, Vanimo and other villages are relatively small. However, neighbouring Indonesia has a much higher power demand. This EIS does not include distribution of power to other users; however, there is potential for a Stage 2 of the SPGP to be developed, which would allow for further high voltage transmission networks to support industrial and population growth and to potentially export to customers in the northwest of PNG and population centres in neighbouring Indonesia.

Once the FRCGP is decommissioned at closure, the full power generation capacity of the FRHEP can be exported.

#### **5.8.1 Substations**

Three substations will be located along the Northern Transmission Line for the transformation of voltage.

- Transmission substation located at the FRCGP site accommodation village to transform from 132 kV to 275 kV.
- Green River substation located south of Green River to transform from 275 kV to 33 kV and 19.1 kV for distribution.
- Vanimo substation located near Vanimo to transform from 275 kV to 33 kV and 19.1 kV for distribution.

### **5.8.2 Transmission Line**

The double circuit Northern Transmission Line will mainly be supported by suspension towers. Strain towers will be used at locations where additional strength is required including the ends of the transmission line and at locations where the transmission line changes direction. A typical suspension tower for the Northern Transmission Line is shown on Figure 5.15.

The electricity is carried by conductors which will be connected to the towers using insulator strings. The towers will be earthed and will include anti climbing devices and danger signage.

The right of way for the Northern Transmission Line and SWER will be up to 50 m which will be kept clear of trees. The towers will typically be located adjacent to the public road which will allow convenient access for construction and maintenance, however minor access tracks may be required for some towers. The towers will generally be placed to avoid areas prone to flooding and to avoid disturbance to villages.

Any sale and transmission of excess power will occur under a commercial Power Purchase Agreement negotiated with a third party power distributor.

## **5.9 Hazardous Materials Management**

The classification, packaging, labelling and safe transport of dangerous goods will be the responsibility of manufacturers, suppliers and transport operators<sup>1</sup>. Where FRL has these responsibilities, it will comply with the relevant requirements (typically the Australian dangerous goods code (NTC, 2016)) and FRL will seek the advice of the appropriate authority, where necessary. FRL has also prepared hazardous materials management plans as part of the Environmental Management and Monitoring Plans (EMMPs) for the Project, as described in Chapter 12.

Materials to be used that will require specific management procedures include explosives, fuels (diesel and petrol), kerosene, solvents, grease, detergents, hydraulic fluid and process plant reagents.

### **5.9.1 Transportation**

FRL will appoint procurement, supply, logistics and tracking coordinators who will be responsible for transportation requirements.

A transport procedure will be prepared in accordance with International Maritime Organisation requirements and included in relevant company documentation, which will address:

- Loading and unloading procedures.
- Control of emissions and spills.

---

<sup>1</sup> Suppliers and transport contractors will be required to comply with FRL's standards, which will be defined in their contracts.

- Ocean shipping, container, barge and truck tracking.
- Cargo security.
- Cleanup and contingency procedures.
- Vehicle cleaning procedures.
- Operator training and audit procedures.

Responsibility for each aspect of dangerous goods transport, handling and storing will be clearly established. Written agreements between FRL and each of the producers, stevedores and transporters will address the following:

- Packaging as per the relevant authority (United Nations (for international sector) and PNG).
- Labelling.
- Transport to and from the Project.
- Unloading at the Project.
- Safety of transportation vehicle and security during transportation.
- Training of handlers during transportation and unloading.
- Emergency response for the duration of the transportation.

### **5.9.2 Storage, Handling and Disposal**

Storage and handling of hazardous substances will be in accordance with the national Australian Standard Storage and Handling of Workplace Dangerous Goods (NOHSC, 2001). A register will be maintained by FRL that will include information cards (which will be displayed as required in Tok Pisin as well as English) and material safety data sheets, prepared by manufacturers or suppliers. Containers of hazardous substances will be labelled in both Tok Pisin and English.

A dangerous goods management procedure will be developed by FRL and will include the following:

- Lists of dangerous goods and their quantities and locations.
- Required handling and storage practices.
- Safety and hazard management.
- Audit procedures.
- Contingency, clean-up and disposal procedures.
- Evacuation and crisis.
- Personnel training procedures.

Waste oils, solvents and other hazardous materials will be collected in drums and stored in bunded areas until disposal in the waste disposal facility or at another approved location.

### **5.9.3 Fuel and Oil**

Bulk fuel storage will be located at the Vanimo Infrastructure Area and MIA as described below:

- Vanimo Infrastructure Area: approximately 24 ML or 75 days' storage of diesel and lubrication oil.
- MIA: approximately 5 ML or 15 days' storage of diesel and 14 days storage for lubrication oil.

Diesel will be delivered via tanker trucks from the Vanimo Infrastructure Area to the MIA where diesel will be stored in large tanks inside the bulk fuel storage area. The tanks will be contained within a bunded area to contain potential spills, which will be collected and directed to an oily water separator, where the oily water will be separated before being discharged into the environment. Waste oil collected will be pumped to a self-bunded waste oil tank.

FRL will maintain a fuel and oil storage log, including the following information:

- Types and volumes of fuel and oils in use.
- Locations of storage facilities and storage (both primary and secondary containment) methods.
- Pumping, piping, transfer and separation procedures.
- Fire protection measures.
- Spill containment and clean-up procedures.
- Maintenance, testing and audit procedures.
- Waste oil collection, treatment, recycling/disposal procedures.

Additional self-bunded fuel tanks will be located at the open-pit and quarry sites, waste barging facility and emergency diesel generators.

#### **5.9.4 Gas**

Liquid petroleum gas (LPG) and compressed oxygen (O<sub>2</sub>) tanks will each be stored separately, and in isolation. Installation and operation of these storage facilities will be in accordance with the PNG environmental code of practice for vehicle/machinery workshops and petroleum storage/resale/usage sites (DEC, 1997) and relevant Australian standards (including the Australian and New Zealand standard for the storage and handling of LP gas (AS/NZS 1596:2014).

#### **5.9.5 Explosives**

Explosives and blasting accessories will be stored separately in a secure magazine compound. The explosives storage and preparation plant for the mine will be located near the limestone quarry within the Ok Binai catchment (see Figure 1.2). This compound will consist of a bulk explosive storage and preparation pad (100 m x 50 m), explosives storage magazine (65 m x 40 m), access roads between each area and a high-security perimeter fence.

The explosive facilities will be self-sufficient for electricity, water and communications services. An explosives contractor will provide the equipment, buildings and labour required to operate these facilities to the required standards.

### **5.10 Construction and Operating Standards**

This section outlines the construction and operation standards for the Project. These vary depending on the Project component.

#### **5.10.1 Design Codes**

Equipment and facilities design and construction will be in accordance with applicable codes for PNG. Where no PNG codes or standards exist, designs will be in accordance with the appropriate codes, regulations or standards for Australia. If there are no PNG or Australian standards, then appropriate international standards will be used, e.g., those of the American National Standards Institute (ANSI) or the International Standards Organisation (ISO). Other guidelines have been considered during the design of specific facilities including:

- ANCOLD and ICOLD for design of the ISF.
- Canadian Dam Association dam safety guidelines (CDA, 2007).
- New Zealand Standard Seismic Performance of Engineering Systems in Buildings, (NZS 4219:2009) for design of marine structures.
- US Army Corps of Engineers Shore Protection Manual for marine structures.

- Various International Maritime Organisation guidelines.

### **5.10.2 Health and Safety**

The principles that will guide management of the health and safety objectives will largely reflect PanAust's 'Vision and Values' which demonstrate a strong commitment to the health and safety of employees and contractors through a Zero Harm safety objective. The Project will present a diversity of challenges for the management and execution of a safe working environment. The Project will approach health and safety from the overall policy objectives of seeking to achieve zero harm and complying with relevant PNG legislation, including the *Mining (Safety) Act 1977* and regulations.

In keeping with the PanAust Group sustainable development management structure, health and safety has a management framework consisting of a defined strategy that will be captured through one or more management plans. Relevant procedures and work instructions will be developed to enable the delivery of the management plan on a day-to-day basis, tailored to meet the need to mitigate the risk of identified workplace and other Project-related hazards.

The development of the Health and Safety Management Plan, Emergency Response Plan and associated procedures and work instructions will be informed through FRL's risk management activity, in common with other sustainable development areas of activity.

Similarly, performance targets will be set to enable continuous improvement based on FRL's monitoring and evaluation of sustainable development activities.

## **5.11 Workforce**

### **5.11.1 Approach to Recruitment**

Recruitment will focus on sourcing labour within PNG. Expatriates may be employed where suitable skills and experience cannot be sourced within PNG.

FRL has designated six recruitment zones (each including several locations) with decreasing preference for employment including:

- Zone 1: PNG national. Landowning communities in the Special Mining Lease (SML), Mining Lease (ML) and the Lease for Mine Purposes (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. Any other provinces within PNG.
- Zone 5: Australia.
- Zone 6: Asia.

Coaches will be used to transport personnel between points of hire along the public road and mine access roads, the Green River Airport and the mine and FRHEP areas. Riverine vessels will be used to transport personnel from points of hire along the Sepik River. Small aircraft may be used to transport some Zone 2 employees to and from work, with the Frieda River Airstrip used for this.

### 5.11.2 Workforce

The workforce will vary for each Project component and during construction and operation.

During construction, total workforce numbers will peak at about 2,750 for the FRCGP, 2,260 for the FRHEP, 880 for the SIP and 290 for the SPGP. Two shifts of 12 hours each will be in operation and employees will typically work a six week on (42 days) and two week off (14 days) roster.

Operations staff is estimated at approximately 2,080 personnel for the FRCGP, 130 for the FRHEP, 250 for the SIP and 50 for the SPGP. The target proportion for employees from each zone are shown in Table 5.17. Table 5.18 shows the proportion of roles with associated rosters for the FRCGP.

**Table 5.17 Recruitment demographics**

Point of Hire	Target proportion (%)
Zone 1	8
Zone 2	31
Zone 3	31
Zone 4	19
Zone 5	6
Zone 6	5

**Table 5.18 Proportion of roles and rosters**

Role	Proportion (%)	Roster (days on/days off)	Hours per shift
Manager	5	9/5	12
Day worker	40	18/10	12
Continuous shift worker	40	21/10 or 11	12
Southeast Asian expatriates	10	42/14	12
Vanimo / Port Moresby / Brisbane (off site workers)	5	5/2	9

The following shift arrangements will be established to facilitate the FRCGP's 24-hour operation:

- All site work will be based on a nominal 6.00 a.m. to 6.00 p.m. shift.
- Mine and concentrate export facility: a 12-hour day and night shift commencing at 6.00 a.m. and 6.00 p.m., respectively.

## 5.12 Waste Management

FRL is committed to minimising waste to the extent feasible in the context of its operation and to employ measures that continually improve the efficiency with which raw materials, energy and natural resources are used. Environmental waste management facilities, located in the mine area, have been designed to manage the waste streams produced by the mine in accordance with the Environmental Design Criteria including solid waste disposal, waste oil, hazardous waste and tyre disposal (FRL, 2015).

### **5.12.1 Waste Minimisation Strategy**

FRL's aim is to use primary resources efficiently, reduce the volume of non-mine (hereafter referred to as 'waste') waste streams, reduce the toxicity of waste streams, and work with suppliers to mitigate the environmental impacts throughout the full product life cycle and supply chain.

Waste streams generated by the Project are defined in the waste management sub-plans (WMP) developed as part of the EMMPs. The aim of the WMPs will be to effectively manage waste from generation to collection, transport, storage, treatment, recycling and disposal in accordance with FRL's policies and procedures.

Principal objectives of the WMPs will be to:

- Eliminate or minimise waste generation.
- Maximise reuse of waste products in a safe and effective manner, where practical.
- Maximise recycling of waste.
- Limit the adverse effects of waste disposal on the local environment.
- Ensure that all waste management activities comply with legislative requirements, waste industry standards and company guidelines.
- Prevent the attraction or foraging of feral and/or native animals.
- Avoid unacceptable safety risks to communities.

To achieve these objectives, the plan will:

- Promote environmental awareness among FRL employees and associated contractors.
- Clarify acceptable waste management techniques using the waste management hierarchy as a guide.
- Prepare an inventory of waste materials on site.
- Quantify the amount of waste produced.
- Detail storage, handling and disposal processes.
- Promote good housekeeping in work areas and laydown yards, and prompt disposal of non-salvageable waste.

### **5.12.2 Waste Handling and Disposal**

Standard operating procedures related to the safe handling, transportation, storage and disposal of wastes generated by the Project will be developed by FRL as part of the WMP. An environmental waste management facility will be constructed in the mine area and will comprise:

- Unrestricted waste covered area for storage of full and empty waste bins, waste bin cleaning area, storage area for unshredded and shredded vegetation for use in composting, shredder/chipper equipment and bailer for compacting plastic waste for disposal in landfill.
- Restricted waste covered area for storage of full and empty waste bins, drum and can crusher, incinerator and storage area for incinerator waste.
- 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.
- Environmental facility offices.
- Storage area for shipping containers for recycled materials.
- Environmental facility mobile fleet and waste containers.
- Perimeter fence.

Table 5.19 summarises waste generation, handling and disposal for the mine. A waste management facility will be located at the ISF during construction. Operational waste for the FRHEP will be minor and therefore will be disposed of at the mine environmental facility. A waste management facility will also be located at the Vanimo Infrastructure Area.

Accountability for waste movement and disposal will be developed by FRL as part of the FRCGP's environmental management system and individual accountabilities defined through role descriptions and conditions of contracts of employment.

**Table 5.19 Summary of waste generation, handling and disposal**

Waste type	Description of waste stream	Management techniques for treatment, recycling or disposal	Design capacity
<b><i>On-site disposal</i></b>			
Domestic waste	Household garbage, paper and wood.	Disposed into solid waste landfill or incinerated.	50 kg/day of plastics waste. 50 kg/day of cardboard and paper waste.
Oil and grease	Miscellaneous used oil.	Used as fuel for the incinerator where possible.	830 m <sup>3</sup> waste lubricant oils per year. Oil filters produced by the FRCGP.
Sewage	Effluents and solids.	Effluent treated at sewage treatment plants and pumped to process water pond or irrigated on vegetated areas. Solids composted in composting facility.	Site accommodation village – mean day flow of up to 1.0 ML/d. ISF camp – mean day flow of 0.4 ML/d (during construction).
Food and green waste	–	Composted in composting facility and used on vegetated areas.	2,500 kg/day.
Medical waste	Sharps, biological material and other solid waste.	Sharps and biological waste incinerated. Other solid waste disposed of in landfill.	30 kg/day.
Used hydrocarbon clean-up material, oily rags and grease	Oil absorbent and dispersant.	Incinerated.	50 kg/day of hydrocarbon waste (rags, grease, etc.).

**Table 5.19 Summary of waste generation, handling and disposal (cont'd)**

Waste type	Description of waste stream	Management techniques for treatment, recycling or disposal	Design capacity
<b>On-site disposal (cont'd)</b>			
Hydrocarbon impacted soil	Soils contaminated with hydrocarbons.	Incinerated or landfarmed and disposed in landfill.	As required.
Laboratory wastes	Fire assay solids, residues, acid wash waste, flux containers, glass, spillages.	Most waste disposed at landfill; incineration of absorbent material used to contain spillages.	As required.
<b>Off-site disposal</b>			
Workshop wastes	Batteries, oil filters and waste solvents.	Trucked and recycled off site.	As required.
Chemicals and chemical containers	Lime and other reagent containers.	Collection by the supplier for recycling or disposal to an approved waste disposal facility.	As required.
Plastic type materials	PVC pipes and vent bags.	Trucked and recycled off site or disposed in landfill.	As required.
Scrap metal	Grinding balls, brass/copper, steel straps and aluminium cans.	Trucked and recycled off site.	As required.
Tyres	–	Shred and recycle.	Approximately 550 heavy vehicle used tyres per year plus light vehicle tyres.
Rubber and steel combination waste	Conveyor belting, screen panels.	Rubber stripped of steel and steel shipped and recycled off site.	As required.
Miscellaneous wastes	205 L hydrocarbon drums, explosives packaging, computer equipment, concrete, paint containers, fencing material.	Trucked and recycled off site.	Drums and intermediate bulk container waste.

### 5.12.3 Monitoring

Project-specific EMMPs will define FRL's environmental monitoring requirements for the Project, including requirements on the frequency of monitoring, reporting and field and laboratory methods for sampling. FRL's Sustainability Department will be accountable for the monitoring program, under the supervision of the Manager Environment. Further detail is provided in Chapter 12.

### 5.12.4 Energy Review and Opportunity for Efficiency Improvements

FRL is committed to continuous improvement of efficiency of energy use. The use of hydroelectric power to generate the vast majority of the FRCGPs power during operations represents a significant commitment to renewable energy by the Project. The process plant has been designed to maximise gravity flow so as to reduce energy requirements. Similarly, electric powered mining equipment will be used, where possible, to minimise diesel fuel consumption.

A formal management program will be established for the Project whereby monitoring and review mechanisms are implemented as part of the Project's EMMPs (Chapter 12).

Environmental Impact Statement  
Sepik Development Project