Chapter 6

Project Description

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This Environmental Impact Statement, including the Executive Summary, and all chapters of and attachments and appendices to it and all drawings, plans, models, designs, specifications, reports, photographs, surveys, calculations and other data and information in any format contained and/or referenced in it, is together with this disclaimer referred to as the "**EIS**".

Purpose of EIS

The EIS has been prepared by, for and on behalf of Wafi Mining Limited and Newcrest PNG 2 Limited (together the "**WGJV Participants**"), being the participants in the Wafi-Golpu Joint Venture ("**WGJV**") and the registered holders of exploration licences EL 440 and EL1105, for the sole purpose of an application (the "**Permit Application**") by them for environmental approval under the Environment Act 2000 (the "**Act**") for the proposed construction, operation and (ultimately) closure of an underground copper-gold mine and associated ore processing, concentrate transport and handling, power generation, water and tailings management, and related support facilities and services (the "**Project**") in Morobe Province, Independent State of Papua New Guinea. The EIS was prepared with input from consultants engaged by the WGJV Participants and/or their related bodies corporate ("**Consultants**").

The Permit Application is to be lodged with the Conservation and Environment Protection Authority ("**CEPA**"), Independent State of Papua New Guinea.

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Any future development of the Project is subject to further studies, completion of statutory processes, receipt of all necessary or desirable Papua New Guinea Government and WGJV Participant approvals, and market and operating conditions.

Engineering design and other studies are continuing and aspects of the proposed Project design and timetable may change.

NEWCREST MINING LIMITED DISCLAIMER

Newcrest Mining Limited ("**Newcrest**") is the ultimate holding company of Newcrest PNG 2 Limited and any reference below to "Newcrest" or the "Company" includes both Newcrest Mining Limited and Newcrest PNG 2 Limited.

Forward Looking Statements

The EIS includes forward looking statements. Forward looking statements can generally be identified by the use of words such as "may", "will", "expect", "intend", "plan", "estimate", "anticipate", "continue", "outlook" and "guidance", or other similar words and may include, without limitation, statements regarding plans, strategies and objectives of management, anticipated production or construction commencement dates and expected costs or production outputs. The Company continues to distinguish between outlook and guidance. Guidance statements relate to the current financial year. Outlook statements relate to years subsequent to the current financial year.

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Forward looking statements are based on the Company's good faith assumptions as to the financial, market, regulatory and other relevant environments that will exist and affect the Company's business and operations in the future.

The Company does not give any assurance that the assumptions will prove to be correct. There may be other factors that could cause actual results or events not to be as anticipated, and many events are beyond the reasonable control of the Company. Readers are cautioned not to place undue reliance on forward looking statements. Forward looking statements in the EIS speak only at the date of issue. Except as required by applicable laws or regulations, the Company does not undertake any obligation to publicly update or revise any of the forward looking statements or to advise of any change in assumptions on which any such statement is based.

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Newcrest results are reported under International Financial Reporting Standards (IFRS) including EBIT and EBITDA. The EIS also includes non-IFRS information including Underlying profit (profit after tax before significant items attributable to owners of the parent company), All-In Sustaining Cost (determined in accordance with the World Gold Council Guidance Note on Non-GAAP Metrics released June 2013), AISC Margin (realised gold price less AISC per ounce sold (where expressed as USD), or realised gold price less AISC per ounce sold divided by realised gold price (where expressed as a %), Interest Coverage Ratio (EBITDA/Interest payable for the relevant period), Free cash flow (cash flow from operating activities less cash flow related to investing activities), EBITDA margin (EBITDA expressed as a percentage of revenue) and EBIT margin (EBIT expressed as a percentage of revenue). These measures are used internally by Management to assess the performance of the business and make decisions on the allocation of resources and are included in the EIS to provide greater understanding of the underlying performance of Newcrest's operations. The non-IFRS information has not been subject to audit or review by Newcrest's external auditor and should be used in addition to IFRS information.

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Competent Person's Statement

The information in the EIS that relates to Golpu Ore Reserves is based on information compiled by the Competent Person, Mr Pasqualino Manca, who is a member of The Australasian Institute of Mining and Metallurgy. Mr Pasqualino Manca, is a full-time employee of Newcrest Mining Limited or its relevant subsidiaries, holds options and/or shares in Newcrest Mining Limited and is entitled to participate in Newcrest's executive equity long term incentive plan, details of which are included in Newcrest's 2017 Remuneration Report. Ore Reserve growth is one of the performance measures under recent long term incentive plans. Mr Pasqualino Manca has sufficient experience which is relevant to the styles of mineralisation and type of deposit under consideration and to the activity which he is undertaking to qualify as a Competent Person as defined in the JORC Code 2012. Mr Pasqualino Manca consents to the inclusion of material of the matters based on his information in the form and context in which it appears.

HARMONY GOLD MINING COMPANY LIMITED DISCLAIMER

Harmony Gold Mining Company Limited ("**Harmony**") is the ultimate holding company of Wafi Mining Limited and any reference below to "Harmony" or the "Company" includes both Harmony Gold Mining Company Limited and Wafi Mining Limited.

Forward Looking Statements

These materials contain forward-looking statements within the meaning of the safe harbor provided by Section 21E of the Securities Exchange Act of 1934, as amended, and Section 27A of the Securities Act of 1933, as amended, with respect to our financial condition, results of operations, business strategies, operating efficiencies, competitive positions, growth opportunities for existing services, plans and objectives of management, markets for stock and other matters. These include all statements other than statements of historical fact, including, without limitation, any statements preceded by, followed by, or that include the words "targets", "believes", "expects", "aims", "intends", "will", "may", "anticipates", "would", "should", "could", "estimates", "forecast", "predict", "continue" or similar expressions or the negative thereof.

These forward-looking statements, including, among others, those relating to our future business prospects, revenues and income, wherever they may occur in this EIS and the exhibits to this EIS, are essentially estimates reflecting the best judgment of our senior management and involve a number of risks and uncertainties that could cause actual results to differ materially from those suggested by the forward-looking statements. As a consequence, these forward-looking statements should be considered in light of various important factors, including those set forth in these materials. Important factors that could cause actual results to differ materially from estimates or projections contained in the forward-looking statements include, without limitation: overall economic and business conditions in South Africa, Papua New Guinea, Australia and elsewhere, estimates of future earnings, and the sensitivity of earnings to the gold and other metals prices, estimates of future gold and other metals production and sales, estimates of future cash costs, estimates of future cash flows, and the sensitivity of cash flows to the gold and other metals prices, statements regarding future debt repayments, estimates of future capital expenditures, the success of our business strategy, development activities and other initiatives, estimates of reserves statements regarding future exploration results and the replacement of reserves, the ability to achieve anticipated efficiencies and other cost savings in connection with past and future acquisitions, fluctuations in the market price of gold, the occurrence of hazards associated with underground and surface gold mining, the occurrence of labour disruptions, power cost increases as well as power stoppages, fluctuations and usage constraints, supply chain shortages and increases in the prices of production imports, availability, terms and deployment of capital, changes in government regulation, particularly mining rights and environmental regulation, fluctuations in exchange rates, the adequacy of the Group's insurance coverage and socio-economic or political instability in South Africa and Papua New Guinea and other countries in which we operate.

For a more detailed discussion of such risks and other factors (such as availability of credit or other sources of financing), see the Company's latest Integrated Annual Report and Form 20-F which is on file with the Securities and Exchange Commission, as well as the Company's other Securities and Exchange Commission filings. The Company undertakes no obligation to update publicly or release any revisions to these forward-looking statements to reflect events or circumstances after the date of this EIS or to reflect the occurrence of unanticipated events, except as required by law.

Competent Person's Statement

The Wafi-Golpu Joint Venture is an unincorporated joint venture between a wholly-owned subsidiary of Harmony Gold Mining Company Limited and a wholly-owned subsidiary of Newcrest Mining Limited.

The information in the EIS that relates to Golpu Ore Reserves is based on information compiled by the Competent Person, Mr Pasqualino Manca, who is a member of The Australasian Institute of Mining and Metallurgy. Mr Pasqualino Manca, is a full-time employee of Newcrest Mining Limited or its relevant subsidiaries, holds options and/ or shares in Newcrest Mining Limited and is entitled to participate in Newcrest's executive equity long term incentive plan, details of which are included in Newcrest's 2017 Remuneration Report. Ore Reserve growth is one of the performance measures under recent long term incentive plans. Mr Pasqualino Manca has sufficient experience which is relevant to the styles of mineralisation and type of deposit under consideration and to the activity which he is undertaking to qualify as a Competent Person as defined in the JORC Code 2012. Mr Pasqualino Manca consents to the inclusion of material of the matters based on his information in the form and context in which it appears.

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6. PROJECT DESCRIPTION

The Wafi-Golpu Joint Venture (WGJV) Participants propose to construct and operate (and ultimately close) an underground copper-gold mine and associated ore processing, concentrate transport and handling, power generation, water and tailings management, and related support facilities and services (hereafter the "Wafi-Golpu Project" or the "Project") in the Morobe Province of Papua New Guinea.

The Project comprises four phases:

- Permitting the Project, including the evaluation, negotiation and approval of the WGJV Participants' application for a special mining lease and other associated tenements under the *Mining Act 1992* and an environment permit under the *Environment Act 2000*
- Construction of an underground mine and ancillary infrastructure, including: decline development; ore processing; concentrate, tailings, fuel and water transport and handling facilities; power generation facilities; access roads and other related ancillary infrastructure
- Operation of the mine and ancillary infrastructure
- Closure of the mine and ancillary infrastructure, including rehabilitation after the end of the Life of Mine (LOM)

This chapter describes the proposed activities and facilities that comprise the Project. For context, the chapter starts with an overview of the geographic, climatic, social and cultural heritage setting of the Project as each of these have shaped the currently-proposed arrangement of the Project.

The general location of Project facilities is shown in Figure 1.1.

Future development of the Project remains subject to ongoing deep orebody drilling and definition (after underground access has been achieved), technical studies, completion of statutory permitting processes and securing Government and WGJV Participants' approvals. Engineering design and other studies, including environmental studies, are continuing and there is potential that aspects of the proposed Project design, layout and timetable may change.

6.1. Project Setting

This section provides an overview of the geographic, climatic setting, social and cultural heritage of the Project.

6.1.1. Geographic Setting

Geographically, the Project occupies a mine to port footprint that extends from the Mine Area to the Coastal Area with an Infrastructure Corridor that links the two areas. Together these discrete areas make up the proposed Project Area:

- **Mine Area**. The area encompassing the proposed block cave mine, underground access declines and nearby infrastructure, including a portal terrace and waste rock dumps supporting each of the Watut and Nambonga declines, the Watut Process Plant, power generation facilities, laydown areas, water treatment facilities, quarries, wastewater discharge and raw water make-up pipelines, raw water dam, sediment control structures, roads and accommodation facilities for the construction and operations workforces.
- **Infrastructure Corridor.** The area encompassing the proposed Project infrastructure linking the Mine Area and the Coastal Area, being corridors for pipelines and roads and associated laydown areas. The proposed concentrate pipeline, terrestrial tailings

pipeline and fuel pipeline will connect the Mine Area to the Coastal Area. A proposed Mine Access Road and Northern Access Road will connect the Mine Area to the Highlands Highway. New single-lane bridges are proposed over the Markham, Watut and Bavaga rivers. Laydown areas will be located at key staging areas.

- **Coastal Area.** The Coastal Area includes the proposed Port Facilities Area and the proposed Outfall Area:
    - **Port Facilities Area**. Located at, or in proximity to, the Port of Lae, with a site adjacent to Berth 6 (also known as Tanker Berth) nominated as the preferred option. The proposed facilities will include the concentrate filtration plant and materials handling, storage, ship loading facilities and filtrate discharge pipeline.
    - **Outfall Area**. Located approximately six kilometres east of the port. The proposed facilities will include the Outfall System comprising the mix/de-aeration tank and associated facilities, seawater intake pipelines and DSTP outfall pipelines, pipeline laydown area, choke station, access track and parking turnaround area.

The Mine Area is located on the northern side of the Owen Stanley Ranges of Papua New Guinea (PNG), approximately 65km from the Port of Lae, in the foothills of the Watut River catchment. The elevation of the Mine Area ranges from approximately 100 metres above sea level (mASL) adjacent to the Lower Watut River to 380mASL near the ventilation shaft. The Mine Area includes land which is steep, mountainous and covered by dense tropical rainforest to the east, and the floodplain of the Lower Watut River to the west.

The Infrastructure Corridor originates at the Watut Process Plant and traverses northwards along the Watut River valley. It crosses both the Watut and Markham rivers, to a point just south of the Highlands Highway, where the corridor intersects the PNG Power high-voltage transmission line. At this point, the pipelines separate from the Northern Access Road to travel east, following the PNG Power high-voltage transmission line to approximately 3km west of the settlement of Yalu on the Highlands Highway. There, the Infrastructure Corridor will deviate from the PNG Power high-voltage transmission line, heading southeast through partially-cleared forest and gardens, and along the upper terrace of the Markham River floodplain, to a point just north of the Port of Lae (refer to Figure 1.1).

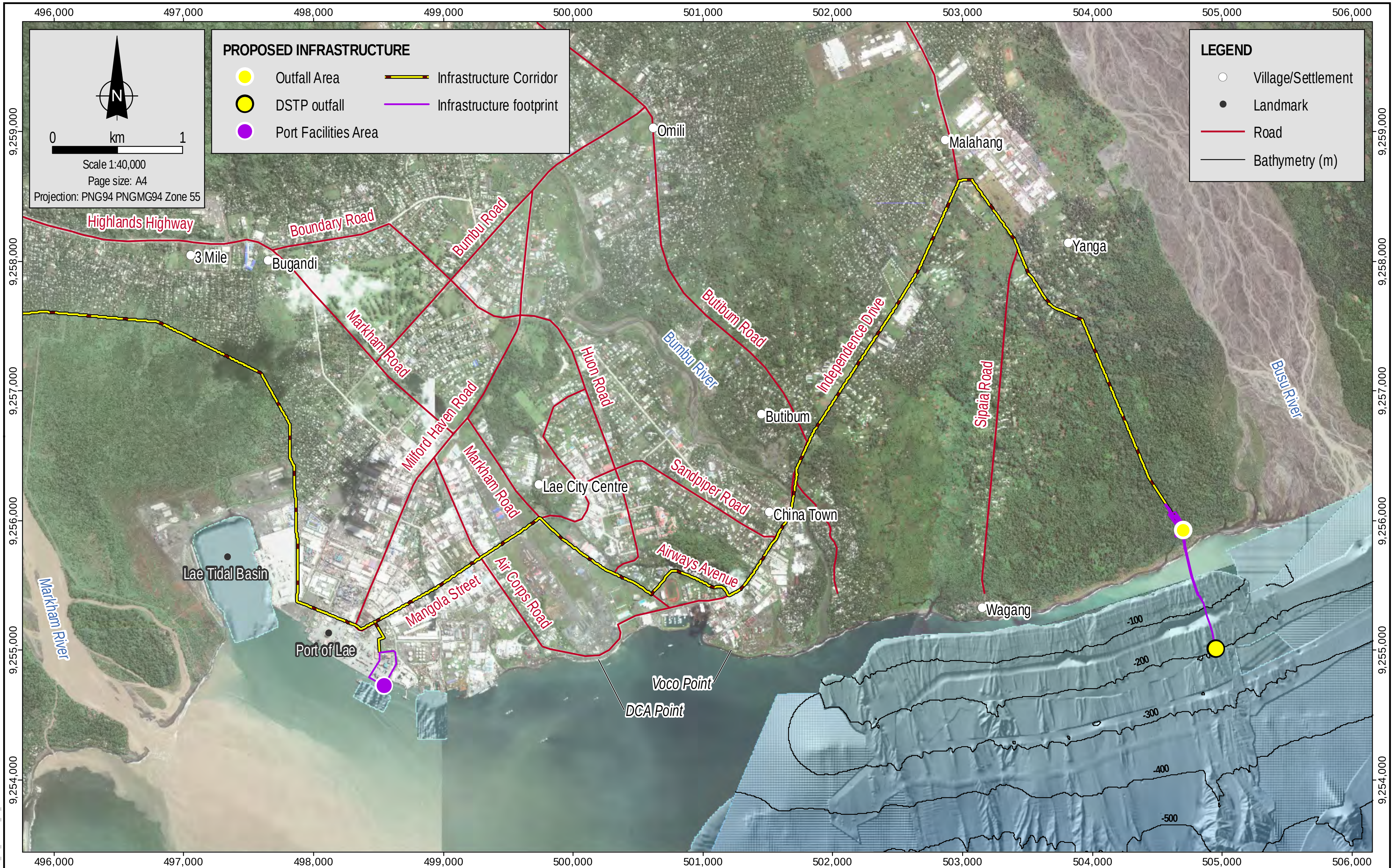
The concentrate and fuel pipelines terminate at, or near, the Port Facilities Area at the Port of Lae; however, the Infrastructure Corridor continues through Lae to the Outfall Area, located between the Wagang settlement and the mouth of the Busu River (Figure 6.1).

6.1.2. Climatic Setting

The Mine Area has a high rainfall and two distinct seasons: a dry season from June to September and a rainy season from December to March. The average annual rainfall for the Mine Area is 2,836 millimetres (mm). The Mine Area is also characterised by low wind speeds, high humidity and warm temperatures with an average maximum of 28 degrees Celsius (°C) and an average minimum of 21°C).

The climatic setting of the Infrastructure Corridor depends on its proximity to the Mine Area (see above) or Coastal Area (see below).

The Coastal Area also experiences two distinct seasons: a southeast monsoon from mid-May to October and a northwest monsoon from mid-November to the end of March, with intervening periods of light, variable winds. Trade winds in the Coastal Area during the southeast monsoon are moderate, and annual rainfall is between 3,900mm to 4,500mm with rainfall peaking between May and August.



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Source:
Villages/Settlements, landmarks and infrastructure from WGJV and Coffey.
Bathymetry from WGJV survey.
Imagery from WGJV (capture date 2016) and ArcGIS Online (capture date unknown).

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Project: 754-ENAUABTF100520DD
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WAFI-GOLPU JOINT VENTURE

Wafi-Golpu Project

Coastal Area

Figure No: 6.1

6.1.3. Social Setting

Villages in and around the Mine Area are inhabited by the Babuaf, Hengambu and Yanta cultural groups. The combined population of these villages is approximately 3,900. Approximately 6,000 people live in the villages on the Lower Watut and Lower Markham rivers (including those along the existing Demakwa Access Road and the section of the proposed Infrastructure Corridor between the Mine Area and Zifasing). These villages are generally inhabited by people of the Wampar cultural group. The Wampar villages, and the Babuaf, Hengambu and Yanta villages, are located in a remote rural area. Residents are generally dependent on the natural environment for food, housing materials, firewood and medicine, which they either grow in gardens or gather from surrounding forests. Houses are predominately made from local materials with wooden posts and frames, timber or bamboo walls, and sago leaves or grass used for roofs. A widespread system of bush tracks provides access between villages. Villagers also use the Lower Watut River, travelling by raft or canoe, to access markets downstream. The existing Wafi Access and Demakwa Access roads are used by public motor vehicles to provide vehicular access to Lae and beyond.

From Zifasing, the Infrastructure Corridor will turn east towards Yalu village, and southeast from Yalu village to Lae. This section of the Infrastructure Corridor traverses villages and settlements including the villages of Ganef, Gabsongkeg, Nasuapum and Munum. This area is predominantly rural, and includes a number of agricultural enterprises (such as chicken farms and palm oil plantations). Between Yalu and Lae, the area is peri-urban, with a mix of rural, industrial, commercial and residential.

Lae is an urban area, a major transport hub, and a commercial, administrative, industrial, residential and educational centre for both the Morobe Province and PNG, with a population in 2011 (the most recent year for which PNG census data is available) of approximately 149,000. The Port Facilities Area is proposed to be located within the gazetted area of the Port of Lae.

The terrestrial tailings pipeline will traverse parts of the city of Lae north and east to Wagang and Yanga villages, two peri-urban villages to the east of Lae. In Wagang and Yanga villages, the majority of households undertake subsistence agriculture, hunting and fishing, but many also undertake employment or business activities in Lae. Residents of these villages typically have access to electricity from the grid and water is supplied variously from springs, creeks, rainwater tanks and well.

Between the village of Yalu and the Port Facilities Area, where the concentrate and fuel pipelines will terminate, communities are situated in a peri-urban setting along the Highlands Highway. Residential settlement becomes markedly denser in the approach to Lae.

6.1.4. Cultural Heritage Setting

Cultural heritage has both tangible and intangible aspects. Tangible heritage includes physical artefacts and objects, whether movable or immovable. Intangible heritage includes oral traditions passed down through generations that are reflected in practices, expressions, knowledge and skills that communities identify as part of their cultural heritage. In PNG, cultural heritage can include oral tradition sites (including spiritual and oral history sites of importance to landowners), historic sites (associated with PNG's colonial history and World War II) and archaeological sites (which contain physical evidence of past cultural activity, such as ancient pottery, stone tools and skeletal remains).

There are five cultural groups relevant to the Project. The Babuaf, Hengambu and Yanta are the main cultural groups that live in proximity to the Mine Area. The Infrastructure

Corridor crosses land claimed by the Babuaf, Wampar and Ahi people. The Outfall Area is also located within land traditionally inhabited by the Ahi people.

Twelve cultural heritage surveys have been completed for the Wafi-Golpu Project since 1996. As a result of consultation with the Hengambu, Yanta, Babuaf, Wampar and Ahi cultural groups and archaeological field surveys, 351 cultural heritage sites have been recorded within, and in the areas broadly surrounding, the Mine Area, Infrastructure Corridor and Outfall Area. These recorded sites include 289 oral tradition sites, 59 archaeological sites and three historical sites. Oral tradition sites include the sites of former settlements, stories, cemeteries, burials, rockshelters and camps.

6.2. Project Facilities Overview

Proposed Project facilities and their estimated disturbance areas are listed in Table 6.1. These areas have been used as the basis of the impact assessments presented in this EIS.

The disturbance areas for Project facilities in Table 6.1 include the area to be occupied by the facility itself plus any additional clearance required for the facility construction. Buffers to the area to be disturbed to construct Project infrastructure were applied to account for coincidental disturbance during construction and to allow for localised refinement during detailed design. As such, the area of disturbance is a conservative estimate.

Table 6.1: Project facilities and disturbance areas

Project Infrastructure and Facilities	Estimated Area of Disturbance (ha)
Mine Area	***374.3***
Block cave mine, declines and subsidence zone	55.1[a]
Watut Declines Portal Terrace and associated infrastructure	30.2
Process plant terrace and associated infrastructure	
Ventilation shaft	1.6
Nambonga Decline Portal Terrace	1.6
Miapilli Waste Rock Dump	7.3
Nambonga Haul Road	25.0
Portal Haul Road	27.0
Wastewater discharge pipeline to the Lower Watut River	8.8
Raw water make-up pipeline from the Lower Watut River to the Watut Process Plant (co-located with the wastewater discharge pipeline), raw water and sedimentation dams	3.0[b]
Accommodation facilities (Fere Accommodation Facility, Finchif Construction Accommodation Facility)	16.4
Power generation facilities	0[c]
Explosives magazines	3.2
Waste management facility (including topsoil stockpiles/laydown areas)	15.6
Migiki Borrow Pit	2.6
Humphries Borrow Pit	1.5
Miapilli Clay Borrow Pit	14.4
Northern Access Road Borrow Pit	56.5
Mt Beamena Quarry, crushed rock stockpiles, offices, workshops and access road	22.7
Mt Beamena spoil and laydown area	43.4

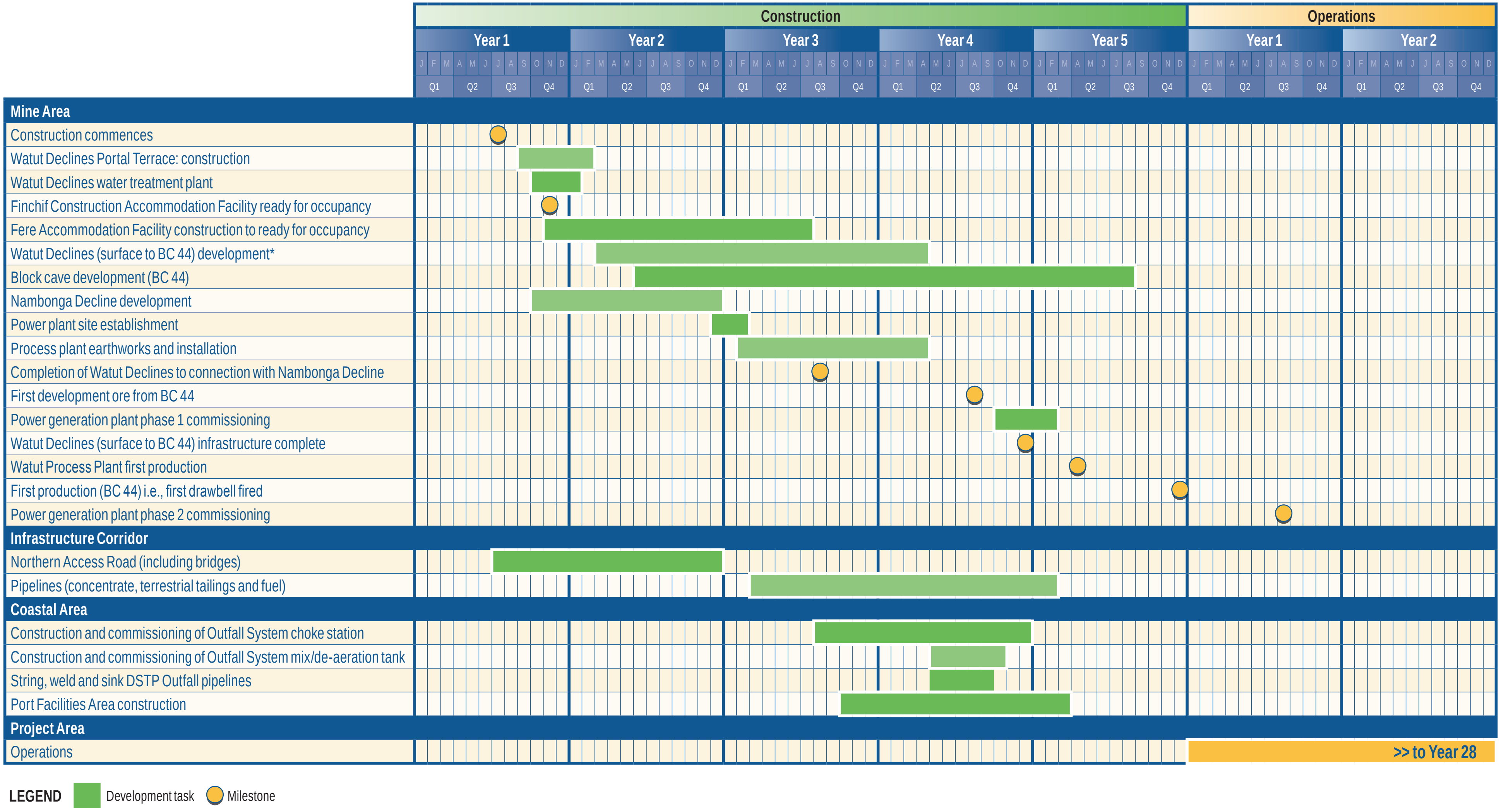
Project Infrastructure and Facilities	Estimated Area of Disturbance (ha)
Bavaga River gravel extraction	9.9
Waime River gravel extraction	0[c]
Lower Papas Aggregate Source and access road	11.4
Lower Papas overburden stockpile	5.5
Crushing, screening, stockpile area (including concrete batch plant)	11.3
Infrastructure Corridor	***707.6***
Mine Access Road	6.0[d]
Link Road	0[c]
Northern Access Road	181.0
Watut Valley Road	85.8[d]
Concentrate pipeline to transport the copper/gold concentrate from the Watut Process Plant to the concentrate filtration plant	378.4[e]
Fuel pipeline from the Port of Lae to the power generation facilities (as required)	
Terrestrial tailings pipeline from the Mine Area to the Outfall Area	20.0[f]
Construction pads, laydown areas and temporary access tracks	36.4
Coastal Area	***7.5***
Port Facilities Area including concentrate filtration plant and materials handling, water treatment plant and filtrate discharge pipeline, concentrate storage and ship loading facilities	3.2
Bulk intermediate fuel oil (IFO) storage facility and fuel pump station at the Port of Lae	0[g]
Outfall System including mix/de-aeration tank, seawater intake pipelines, DSTP outfall pipelines, laydown area, diesel storage, parking and associated access road	2.1
Temporary laydown areas for construction	2.2
Community Roads	***315.8***
Resettlement Road	185.2
Watut Services Road	130.6

[a] Area of disturbance is associated with the subsidence zone only.
[b] Will be within the footprint of the wastewater discharge pipeline.
[c] Denotes an area that has already been cleared.
[d] The majority of the access road follows an existing road. Disturbance area calculations relate to upgrade requirements only.
[e] The concentrate, fuel and terrestrial tailings pipeline will be within the Northern Access Road footprint until Zifasing, where the pipelines head east. The footprint value does not include the Northern Access Road footprints.
[f] The terrestrial tailings pipeline will be co-located with the concentrate and fuel pipelines until the turn-off to the port, within Lae.
[g] The bulk IFO storage facility and pump station will be located on previously cleared third party land.

6.3. Project Development Schedule

Construction activities will take place over an approximate five-year period and operations (commissioning, ramp-up and production) will continue for an estimated 28 years. The post-closure period will commence following the cessation of operations.

A high-level depiction of the current indicative mine development schedule is shown in Figure 6.2. **These timeframes are subject to the completion of statutory processes and the securing of approvals from the State of PNG and the WGJV Participants. Also engineering design and other studies, including environmental studies, are continuing and there is potential that aspects of the proposed Project design, layout and timetable (including the indicative schedule shown in Figure 6.2) may change.**



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WAFI-GOLPU JOINT VENTURE

Wafi-Golpu Project

Indicative mine schedule

Figure No: 6.2

6.4. Mine Area Site Access

The existing Demakwa Access Road, Link Road and Watut Valley Road will provide initial access to the Mine Area during construction, while the Northern Access and Mine Access roads – the preferred, long-term construction and operations transport route for all Mine Area traffic – are developed. Thereafter, the main construction and operations access to the Mine Area will be via the Northern Access Road and the Mine Access Road (see Figure 1.2).

To facilitate initial access to the Mine Area, minor upgrades to the existing Demakwa Access, Wafi Access, Watut Valley and Nambonga Decline Access roads (see Figure 1.2) are needed to improve road safety and drainage control.

The Northern Access Road and the Mine Access Road will be wholly located in the Infrastructure Corridor. The Mine Access Road will commence at the process plant terrace and follow the existing WGJV-operated Watut Valley Road to its intersection with the existing Link Road. The Northern Access Road will commence at the point of intersection and continue north to the point where it crosses the Watut River, then northeast across the Markham River, approximately 3.5km to the west of its confluence with the Watut River.

It is intended that the Northern Access Road will be a public road. The Mine Access Road will be a private road for the exclusive use of the WGJV and its invitees, controlled via a security access point to the north of the Finchif Construction Accommodation Facility. The Mine Access Road will provide WGJV access to the Fere Accommodation Facility. A short road from the Mine Access Road will also provide WGJV access to the explosives magazine.

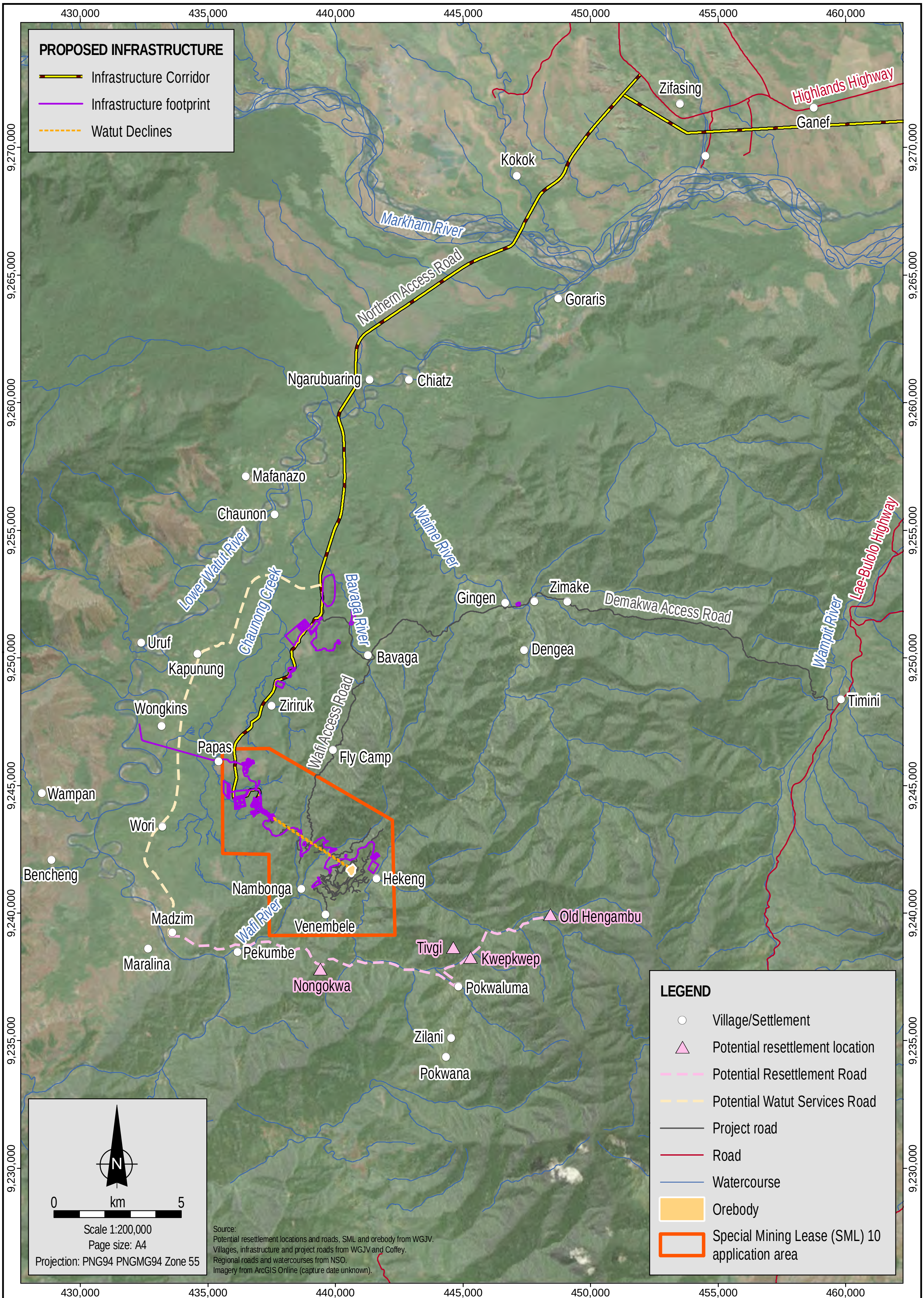
Within the area of the proposed Special Mining Lease, the Mine Access Road will intersect with the Watut Valley Road. The Watut Valley Road will provide WGJV access to the laydown area and waste facilities before arriving at the Watut Process Plant. The Nambonga Decline Access Road will provide WGJV access to the Nambonga Decline Portal Terrace.

Establishment of additional roads is also being investigated for the purposes of providing local community access to the Northern Access Road. Two of the community access road options identified to date are shown on Figure 6.3 and include:

- Watut Services Road providing a transport link between Kapunung and Madzim villages (approximately 20km).
- Resettlement Road from Madzim to Old Hengambu villages (approximately 18km). This road will link Pekumbe, Pokwaluma and old Hengambu with the two currently proposed locations for resettlement villages, Nongokwa and Kwepkwep. The construction of this road depends on the outcome of the resettlement process, as it is intended to provide persons physically displaced by the Project with equivalent or improved road access. As such, the road will ultimately be determined by the location to which displaced persons are relocated.

It is anticipated that any community access roads established will be public roads.

Section 6.18 provides further information regarding the resettlement arrangements for the Project.



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coffey A TETRA TECH COMPANY	Date: 12.06.2018 Project: 754-ENAUABTF100520DD File Name: 0520DD_10_F06.03_GIS	WAFI-GOLPU JOINT VENTURE Wafi-Golpu Project	Preliminary community access roads options	Figure No: 6.3

6.5. Mine Area Preparation

6.5.1. Vegetation Clearance

The proposed areas for the Watut Declines Portal, plant terrace and Watut Waste Rock Dump are, generally, heavily forested and a vegetation clearance program will be required to enable construction of these facilities. Economically-valuable trees will be cut and transported to a central log storage area for later sale or use by local landowners.

Seeds will be harvested from representative tree and shrub species for use in Mine Area rehabilitation, and sufficient cleared vegetation (leaves and small branches) mulched to provide for bank stabilisation and rehabilitation. Non-commercial timber will be made available to local communities for cooking fuel and building materials. Given the implications for local air quality, burning vegetation will only be used as a last resort to manage cleared vegetation.

As far as practicable, development of facilities associated with the Nambonga Decline makes use of existing facilities, tracks and pads. For example, the Nambonga Decline Portal Terrace and associated bulk air coolers and generators are all proposed to be located on existing pads. The new road to the Miapilli Waste Rock Dump (Nambonga Haul Road), the Miapilli Waste Rock Dump itself and the Miapilli Clay Borrow Pit are proposed to be located on sloping land with secondary regrowth vegetation that has been used for subsistence gardening by the local community.

6.5.2. Watut Declines Portal Terrace

Due to the steep terrain in the area of the planned Watut Declines Portal, a portal terrace is proposed to be built within the Boganchong Creek valley to form a marshalling area for the underground activities.

The ‘high wall’ will be constructed to form a geotechnically-stable, steeply-angled face from which to commence construction of the entrances to the Watut Declines (the portals). The portals are proposed to be located between 230m above sea level (ASL) and 250mASL.

The high wall will necessitate the excavation of approximately 300,000 cubic metres (m^3) of material, which will be used for construction of the portal terrace and the Portal Haul Road, the latter providing road access between the process plant terrace and the portal terrace. Excavated material will be exclusively Babuaf Conglomerate. This rock type is non-acid forming (NAF) (see Section 6.7.1) and excavated material will be placed above a buried stormwater drainage culvert within the portal terrace. Water management for this facility is described in Section 6.9.

Weep drains of varying lengths will be installed across the face of the high wall to de-pressurise the slope. Soil nails, mesh and fibre-reinforced shotcrete will also be applied as erosion protection and to support and stabilise the wall.

The portal terrace will be constructed on fill material bounded by the valley walls as shown in Figure 6.4 and the downstream extension of this terrace will include the planned Watut Waste Rock Dump (see Section 6.7.2.2). The facilities located on this terrace are listed in Table 6.1.

6.5.3. Nambonga Decline Portal Terrace

The Nambonga Decline Portal Terrace will be constructed to provide a consolidated location for infrastructure associated with the Nambonga Decline.

The concept design of the Nambonga Decline Portal is based on a reinforced tunnel abutting the high wall and retaining walls along a known landslip zone. The reinforced tunnel will protect the portal entrance from possible future landslides. The extent and application of these measures will be determined once the geotechnical design is complete.

Watut Declines Portal Terrace general arrangement

Figure No: 6.4

An overview of the infrastructure associated with the Nambonga Decline is shown in Figure 6.5.

6.5.4. Watut Process Plant Terrace

The process plant terrace will be constructed as a precursor to the mining operations phase. Its proposed location is shown in Figure 1.2 and a general arrangement of the plant terrace in relation to the Watut Declines Portal Terrace is shown in Figure 6.6. The facilities to be located on this terrace are listed in Table 6.1.

The process plant terrace will be constructed on a ridgeline and requires primarily excavation (cut) to achieve the necessary area to host the Watut Process Plant. The process plant terrace will be made up of three platforms, with a 7 to 12m step between each platform.

6.6. Mining

The shape of the Golpu orebody is near vertical and extends from 200 metres below ground level (mbgl) to a depth of more than 2,000mbgl. As a result, underground mining by block caving is proposed to extract the ore (see Chapter 7, Assessment of Alternatives, for further discussion). Access to the mine workings will be via the Watut and Nambonga declines, with each generating waste rock that will either be used in construction activities, processed or deposited within the waste rock dumps. Block cave mining will not result in the production of waste rock per se because all material extracted from the block cave will be fed to the Watut Process Plant. Block cave mining will cause a subsidence zone of fractured rock to develop that will propagate to surface.

6.6.1. Mining Method

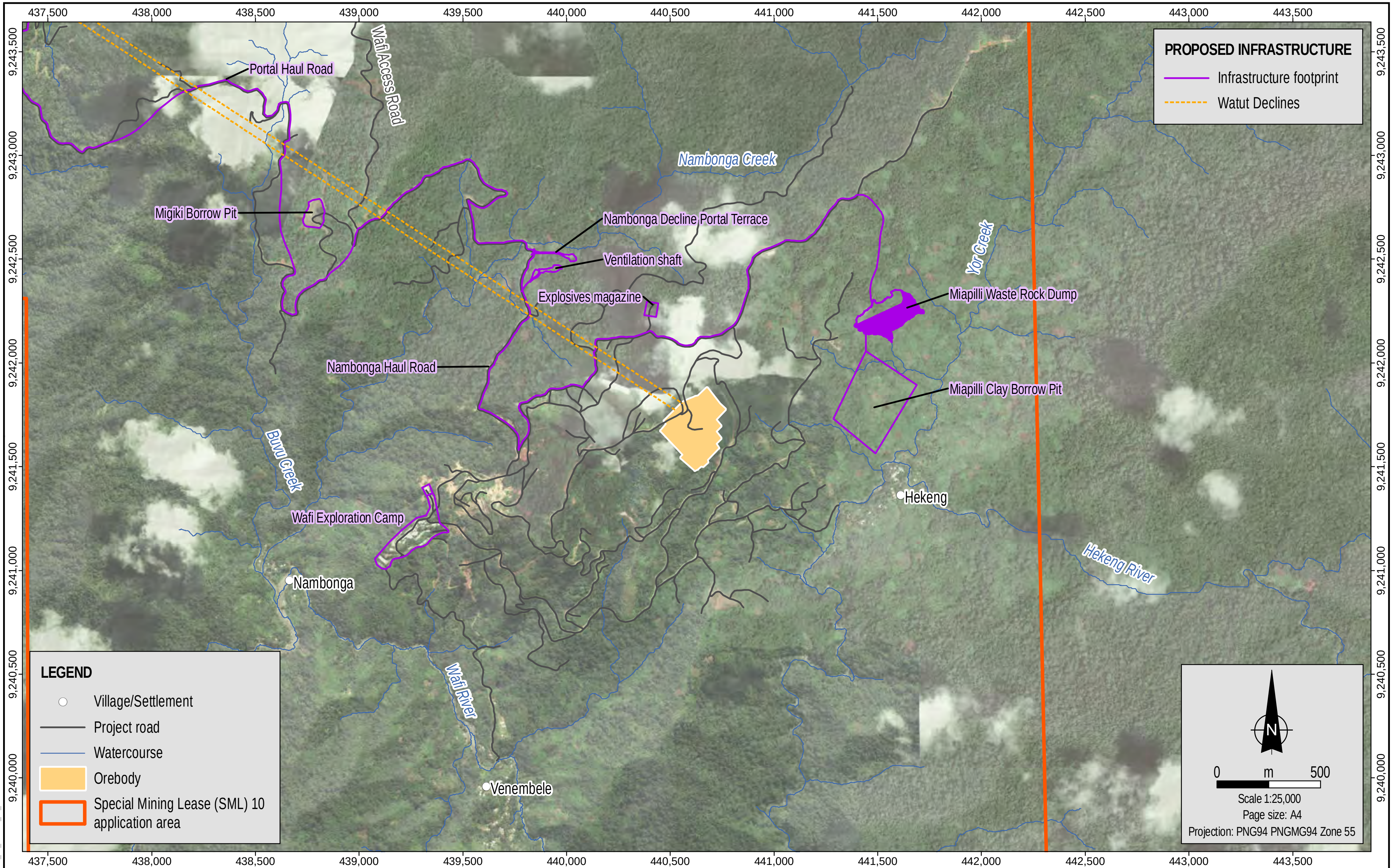
The proposed block caving mining method is a technique using the controlled collapse of a near-vertical orebody as a means of breaking and extracting the ore. This method of underground mining is a low-cost, bulk mining method that minimises the mine footprint. One of the ultimate parent companies of the WGJV Participants, Newcrest Mining Limited, uses the block caving mining method at its Cadia Valley Operations in New South Wales, Australia.

The mine is planned to operate 24 hours per day, every day of the year, apart from scheduled and unscheduled shutdowns.

6.6.1.1. Block Caving

Block caving uses three levels for each block cave (undercut, apex and production/extraction) as shown in Figure 6.7 and described below:

- ‘Undercut’ is the level at which the initial, once-off drilling and blasting takes place to shatter rock at the bottom of the orebody to be mined for that block cave.
- ‘Apex’ is the level at the top of the undercut shape created and is used for monitoring of undercut excavation during the construction phase to ensure correct and complete breakage is achieved by the undercut.
- ‘Production/Extraction’ is situated below the undercut level. This level is linked to the undercut by funnel-shaped excavations known as drawbells through which the broken rock descends. Ore is extracted by load-haul-dump vehicles from a network of draw points. Because the ore in the undercut level is unsupported, once extraction starts, the collapse of the rock in the undercut will continue as long as extraction continues.



MXD Reference: 0520DD_10_GIS048_v0_7

Source:
Watercourses, SML and orebody from WGJV.
Villages, infrastructure and project roads from WGJV and Coffey.
Imagery from WGJV (capture date 2016).

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Wafi-Golpu Project

Infrastructure associated with the Nambonga Decline

Figure No: 6.5

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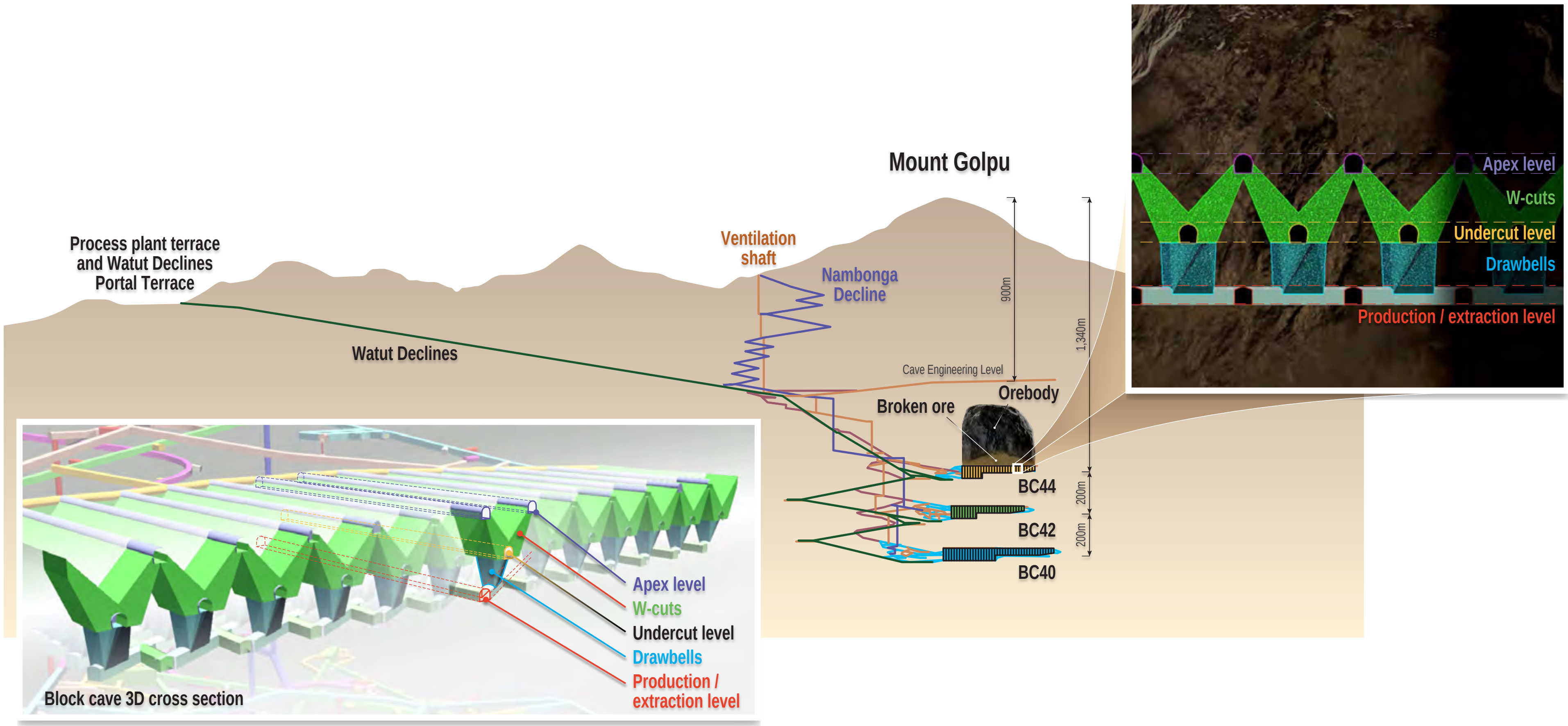
WAFI-GOLPU JOINT VENTURE

Wafi-Golpu Project

Process plant terrace and Watut Declines Portal Terrace infrastructure and general arrangement

Figure No: 6.6



Cave ore production	Year																											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Block Cave 44 (BC44)				7 years																								
Block Cave 42 (BC42)										9 years																		
Block Cave 40 (BC40)																				17 years								

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WAFI-GOLPU JOINT VENTURE

Wafi-Golpu Project

Schematic of the declines and block caves and the block cave production profiles

Figure No: 6.7

Block caving of the orebody is proposed to use three extraction levels. These extraction levels are shown on Figure 6.7. The three extraction levels, described as Block Cave (BC) 44, BC 42 and BC 40, will operate concurrently for a number of years; hence, the individual 'lives' of the block caves are not additive, as depicted in Figure 6.7.

During the development of the block caving infrastructure, ore grade material will be temporarily stockpiled on the process plant terrace for later use during commissioning and initial production from the process plant.

During caving operations, ore from the block cave drawpoints will be delivered by load-haul-dump vehicles to an underground crusher. The crushed ore will then be conveyed to the surface.

The ore conveyor emerging at the Watut Declines Portal Terrace will continue overland for approximately 600m to deliver crushed ore to a coarse ore stockpile adjacent to the Watut Process Plant for processing.

6.6.1.2. Underground Access

The twin Watut Declines will provide access to the underground operations from the Watut Declines Portal Terrace, and the Nambonga Decline will provide access from the Nambonga Decline Portal Terrace (see Figure 1.2).

During mining, the Watut Declines will provide underground access for personnel and equipment, allow ore to be brought to the surface via conveyors, host reticulated services such as power and water, and form part of the ventilation circuit. The Nambonga Decline will intersect the two Watut Declines and, once connected, it will eventually transition to ventilation and emergency egress.

The declines will be supported by refrigeration and ventilation systems and a dewatering system for groundwater entering the declines.

6.6.1.2.1. Watut Declines

The finished Watut Declines will be approximately 6.4m high, 5.4m wide, with a horizontal separation of approximately 25m, and extend from the surface at the portal terrace to the bottom of BC 44, a linear distance of approximately 4,600m.

From BC 44, a system of access and conveyor declines and a return air system will be developed to the base of BC 42, located 200m below the base of BC 44. The access decline will be used to move personnel and equipment between the surface and the working areas of the mine while the conveyor decline will host the conveyor for transporting ore from the block caves to the Watut Process Plant and other services such as power, compressed air and water. The return air system will exhaust air from the block caves to the ventilation shaft. Fresh air will be pushed into the mine via the declines. A similar approach will be used to access BC 40 from BC 42.

The Watut Declines will be excavated using drill and blast techniques with the waste rock trucked to the surface for disposal in a waste rock dump.

Rock encountered near the surface will be non-acid forming (NAF) Babuaf Conglomerate, while potentially acid-forming (PAF) rock is expected in the later stages of decline development within the altered metasediment. The acid-forming potential of the excavated rock will be confirmed ahead of the decline face by cover drilling and used to determine where it will be disposed within the waste rock management system.

Further information on the waste rock dump design, geochemical characteristics and estimated quantities of NAF and PAF material requiring storage is provided in Section 6.7.

A schematic illustration showing the locations of the declines, block cave, ventilation shaft and infrastructure is provided in Figure 6.7.

6.6.1.2.2. Nambonga Decline

The Nambonga Decline will be approximately 6.8m high and 5.6m wide for the first 300m and thereafter reduce to approximately 5.7m high and 5.2m wide, and extend from the surface at the Nambonga Decline Portal Terrace to intersect the Watut Declines, a linear distance of approximately 3,750m. The general arrangement of the Nambonga Decline is shown in Figure 6.5.

The Nambonga Decline will be developed in three stages:

- Stage 1: Development from the portal to the first drill platform, including ventilation development required to facilitate development and drilling
- Stage 2: Extension of the decline and ventilation infrastructure, and the development of a second drill platform
- Stage 3: Continuation of the decline and other development to integrate with the greater underground mine

Development of the Nambonga Decline will be undertaken using a combination of tunnel excavator and drill and blast methods; the latter are planned for development beyond the initial 300m of decline. All material excavated during the Nambonga Decline development will be hauled to the surface using underground haul trucks and tipped at a transfer point near the portal. There are no plans to produce or transport ore through the Nambonga Decline. The majority of the material to be excavated is expected to be PAF (see Table 6.2). Waste rock from the Nambonga Decline will be managed in a purpose-built waste rock dump (termed the Miapilli Waste Rock Dump) in a valley within the Yor Creek catchment (refer to Section 6.7.2).

The Nambonga Decline will be supported by a range of water management, ventilation, refrigeration, power and ancillary facilities and services.

6.6.1.2.3. Ventilation Shaft

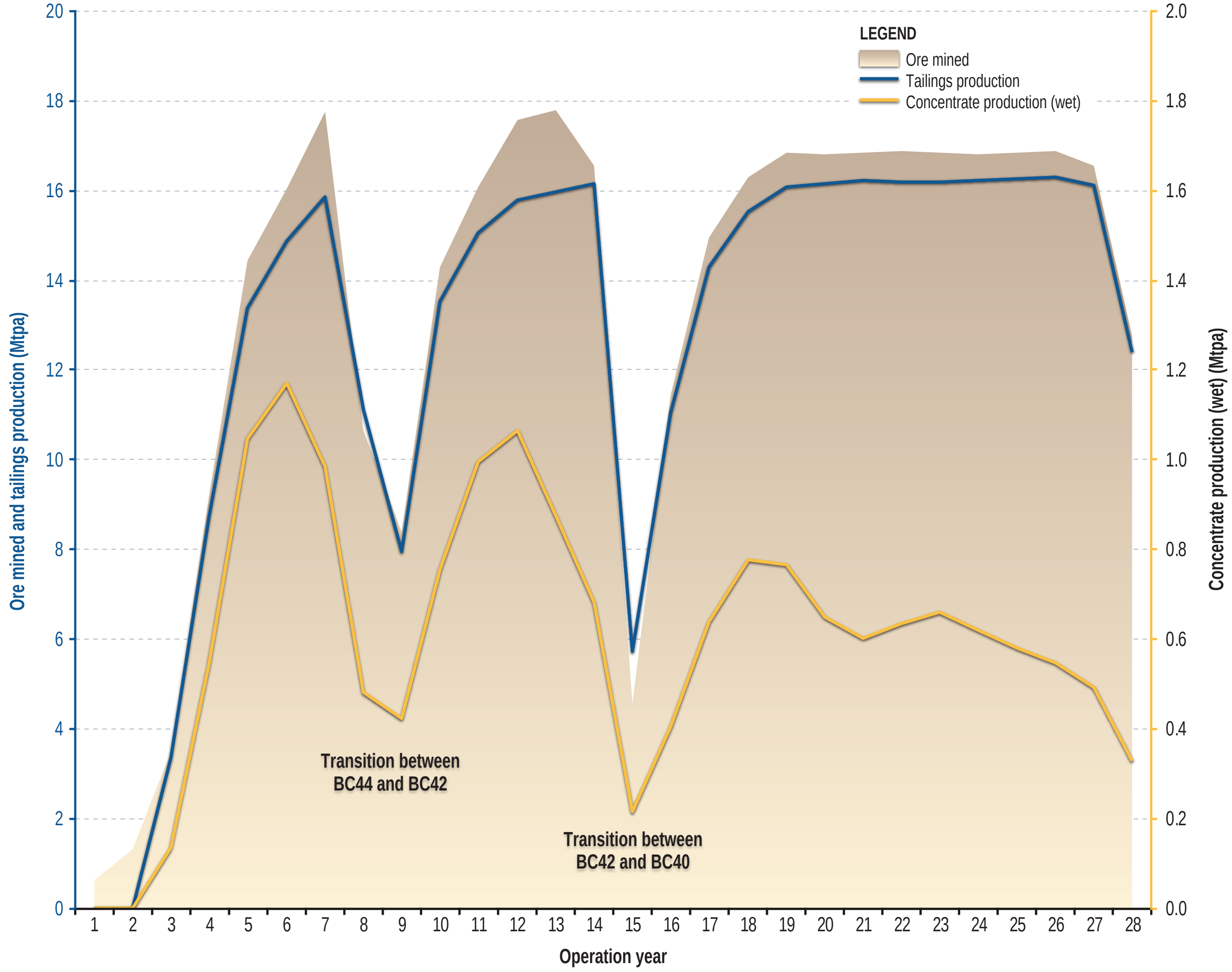
A ventilation shaft system with a finished diameter of approximately 5m will be required to service the additional ventilation demands for the operation of the mine as the underground workings develop. Construction is expected to be timed for the commencement of access to BC 42 (i.e., operations Year 1). Waste rock from the ventilation shaft may be placed in the Waste Rock Dumps or processed through the Watut Process Plant.

6.6.2. Ore Production

The ore production rates are expected to ramp up during the first five years of operations to over 14Mtpa, following which the process plant design production rate of 16.84Mtpa will be reached. Approximately 376Mt of ore will be processed over the Life of Mine.

Once BC 42 subsidence reaches BC 44, the two caves will merge and ore extraction from BC 44 will cease. This will include removal of crushing, conveying and mine services.

Estimated production rates of ore, concentrate and tailings are shown in Figure 6.8.



Note:
Peak annual cave production is 17 Mtpa with development entering the ore stream being additive to the cave production resulting in a peak production of 17.8 Mt

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WAFI-GOLPU JOINT VENTURE

Wafi-Golpu Project

Estimated mine production rates

Figure No: 6.8

6.6.3. Subsidence

Block caving will affect the local topography at the surface above the orebody. The depth of the resultant subsidence zone generally relates to the mass of rock removed by mining while its lateral extent reflects a complex relationship between the surface topography, structural controls below surface (faults and boundaries between rock types) and the width of the orebody below.

The primary surface features developing as a result of block caving may include the following (Lupo, 1998):

- Caved rock zone forming a crater
- Large-scale surface cracking (fractured) zone
- Small-scale surface displacement (continuous surface subsidence) zone
- Stable zone

Block caving experience and behaviour of the subsidence zone on the Cadia Valley Mine (operated by Newcrest) has been considered in the design of the Project.

Figure 6.9 shows the standardised description of subsidence features related to block cave mining (Itasca, 2016; Van As, et al., 2003).

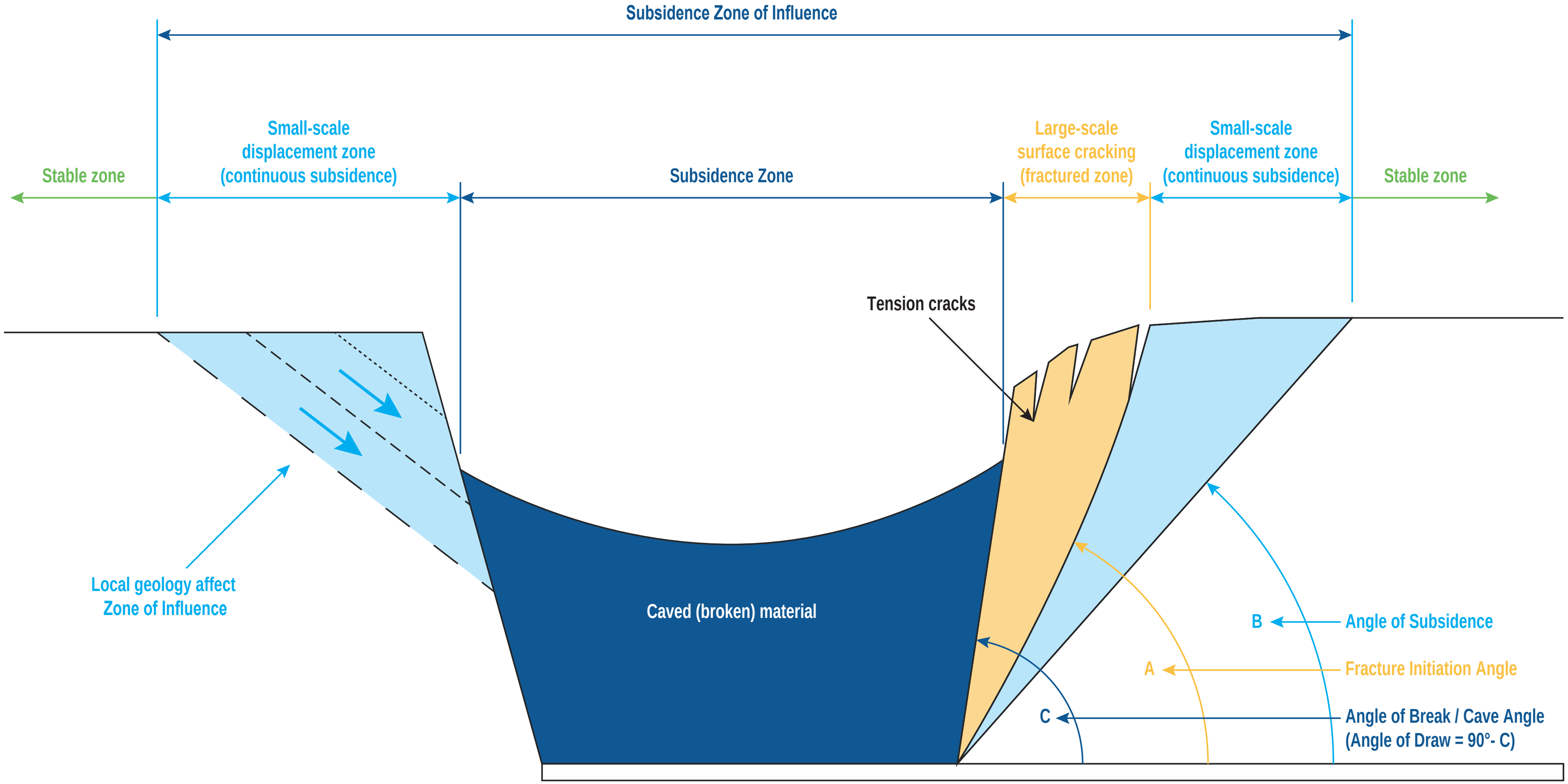
As a result of the subsidence, a subsidence crater is expected to start to form on the ground surface above the orebody approximately 38 months after the start of block caving (as estimated from numerical modelling). The crater created at surface is known as the surface breakthrough or subsidence zone. The extent of the subsidence zone of influence over the surface of the orebody has been modelled to estimate the limits for surface breakthrough, cave interaction and influence on surface infrastructure. A cross section of the predicted subsidence zone of influence at the conclusion of mining is shown in Figure 6.10.

The subsidence crater that will form at the surface as a result of mining the Golpu orebody is predicted to be approximately 975m in diameter with a depth of approximately 400m from the natural ground surface at the conclusion of mining (Itasca, 2018).

Following mine closure and cessation of dewatering, it is predicted that the subsidence zone will eventually become partially filled with rainwater and groundwater, creating a subsidence zone lake. Piteau Associates has modelled the indicative behaviour of the lake and the expected lake water quality. The results of this modelling are discussed in Section 6.9.6 and are included as Appendix X, Assessment of Closure Conditions and Water Management Options for the Wafi-Golpu Block Cave and Subsidence Zone.

6.7. Waste Rock Management

Waste rock is non-economic material that must be excavated from development workings and brought to the surface to gain access to the ore. Once the underground crusher is installed, all rock will be transferred to the underground crusher and delivered to the surface as part of the ore stream for processing. Unlike typical open-cut mines, this means there is effectively no waste rock generated during operations.



Source:
WGJV: 532-1005-EN-REP-0004-1.4, Figure7.5

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WAFI-GOLPU JOINT VENTURE

Wafi-Golpu Project

Schematic showing subsidence features for block cave mines

Figure No: 6.9

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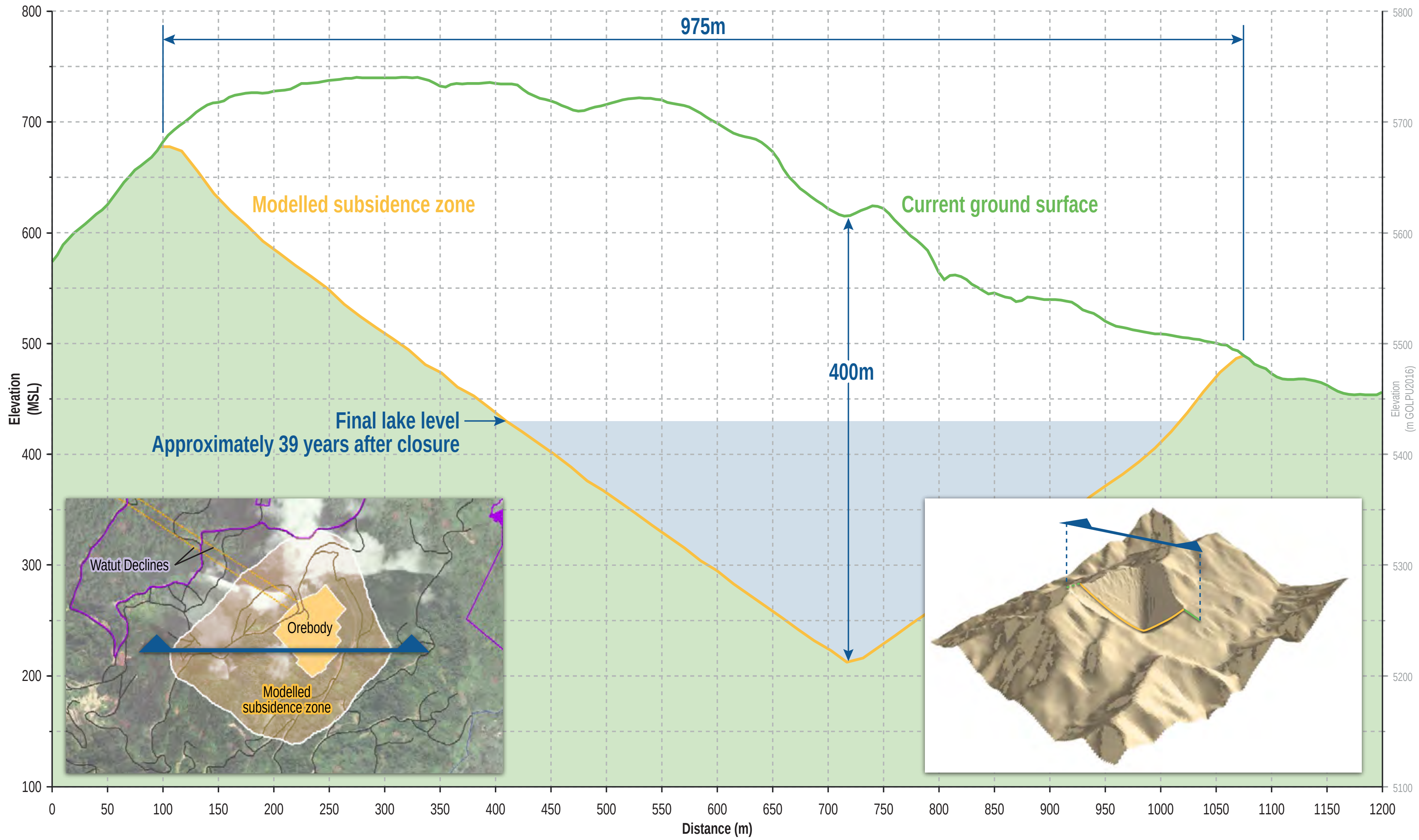

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WAFI-GOLPU JOINT VENTURE

Wafi-Golpu Project

Modelled subsidence zone and final lake approximately 39 years after closure

Figure No: 6.10

The primary factor that determines the requirements for management of waste rock for the Project is its potential to produce acid, and its consequent generation of drainage that is both acidic and contains elevated concentrations of dissolved metals. Geochemical characterisation of mine materials (i.e., waste rock and ore) in and around the Golpu deposit has been conducted on multiple sets of samples obtained between 1990 and 2017, specifically to identify potentially acid forming (PAF) material. Each 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 review of this work has been completed by the geochemistry specialist company SRK Consulting (Australasia) Pty Ltd and the findings of this review are provided as Appendix E, Mine Material Geochemistry. The results of this evaluation have guided the proposed management strategy for the management of waste rock for the Project.

The various geochemical characterisation programs have found that almost all of the ore and much of the waste rock is PAF. As a result, management of the potential for acid and metalliferous drainage (AMD) is a key focus for the Project. This section provides further detail about the production, geochemistry and management of waste rock for the Project.

6.7.1. Waste Rock Production and Geochemistry

A total of approximately 2.40Mt of waste rock is expected to be excavated from the declines and the ventilation shaft during construction. This will be produced from the Babuaf Conglomerate, Babuaf Volcanics, Langimar Beds and Owen Stanley Metamorphics (see Chapter 8, Physical and Biological Environment Characterisation, for further detail about these geologies).

Based on geochemical analysis (see Appendix E, Mine Material Geochemistry), it is expected that waste rock excavated from the Watut and Nambonga declines will comprise approximately 1.87Mt (78%) of material classified as PAF and approximately 0.53Mt (22%) of waste rock classified as NAF, as shown in Table 6.2. Geochemical characterisation of waste rock from the lithologies to be intersected by the declines indicates that, in general, acidification of PAF waste rock (either in waste rock or the subsidence zone) is expected to lead to acidic drainage with elevated metal concentrations, in particular zinc, copper, iron, manganese and other metals.

No geochemical characterisation of the rock to be extracted from the ventilation shaft has been specifically undertaken. However, characterisation of samples taken nearby, from the same rock types as those intersected by the shaft, indicates that the waste rock from the ventilation shaft is likely to be predominantly PAF (and hence for design purposes it has conservatively been assumed this volume of rock would need to be encapsulated in the waste rock dump). As a precautionary measure, waste rock will be geochemically characterised ahead of abstraction by drilling along the decline and ventilation shaft alignment. Waste rock from the ventilation shaft may be placed in the waste rock dumps or processed through the Watut Process Plant.

Table 6.2 defines the waste rock generated from the declines and the estimated approximate volumes and tonnages of NAF and PAF material produced.

Table 6.2: Approximate volume of waste rock to be extracted – declines

Rock Type	Location	Classification	Volume (m^3)	Tonnage (t)
Portal Conglomerate	Watut	NAF	17,539	48,232
Babuaf Volcanics	Watut	NAF	59,051	162,391
Babuaf Conglomerate	Watut	NAF	46,737	128,526
Langimar Beds	Watut	NAF	57,917	159,271

Rock Type	Location	Classification	Volume (m^3)	Tonnage (t)
Weathered Material	Nambonga	NAF	11,650	32,036
NAF Total			**192,893**	**530,456**
Owen Stanley Metamorphics	Watut	PAF	406,280	1,117,269
	Nambonga	PAF	200,082	550,227
Nambonga Porphyry	Nambonga	PAF	74,202	204,055
PAF Total			**680,564**	**1,871,550**
Grand Total			**873,457**	**2,402,006**

Competent NAF material will be used during construction of the Project (e.g., for portal terraces) and as lining and capping for the PAF waste rock cells in the waste rock dumps. The PAF material will be stored in engineered waste rock dumps adjacent or nearby to the Watut and Nambonga declines as described below.

6.7.2. Waste Rock Dump Design

The high acid-forming potential of the waste rock requires a robust management strategy to store PAF material in such a way as to limit exposure to atmospheric oxygen and subsequent formation of AMD. Based on the anticipated characteristics of the majority of the waste rock to be extracted from the Nambonga and Watut declines, PAF material will be stored within purpose-built cells constructed of NAF material or excavated borrow material to limit exposure of the PAF material to atmosphere.

Each waste rock dump's associated drainage systems and channels will be designed to withstand a 1:100 flood event.

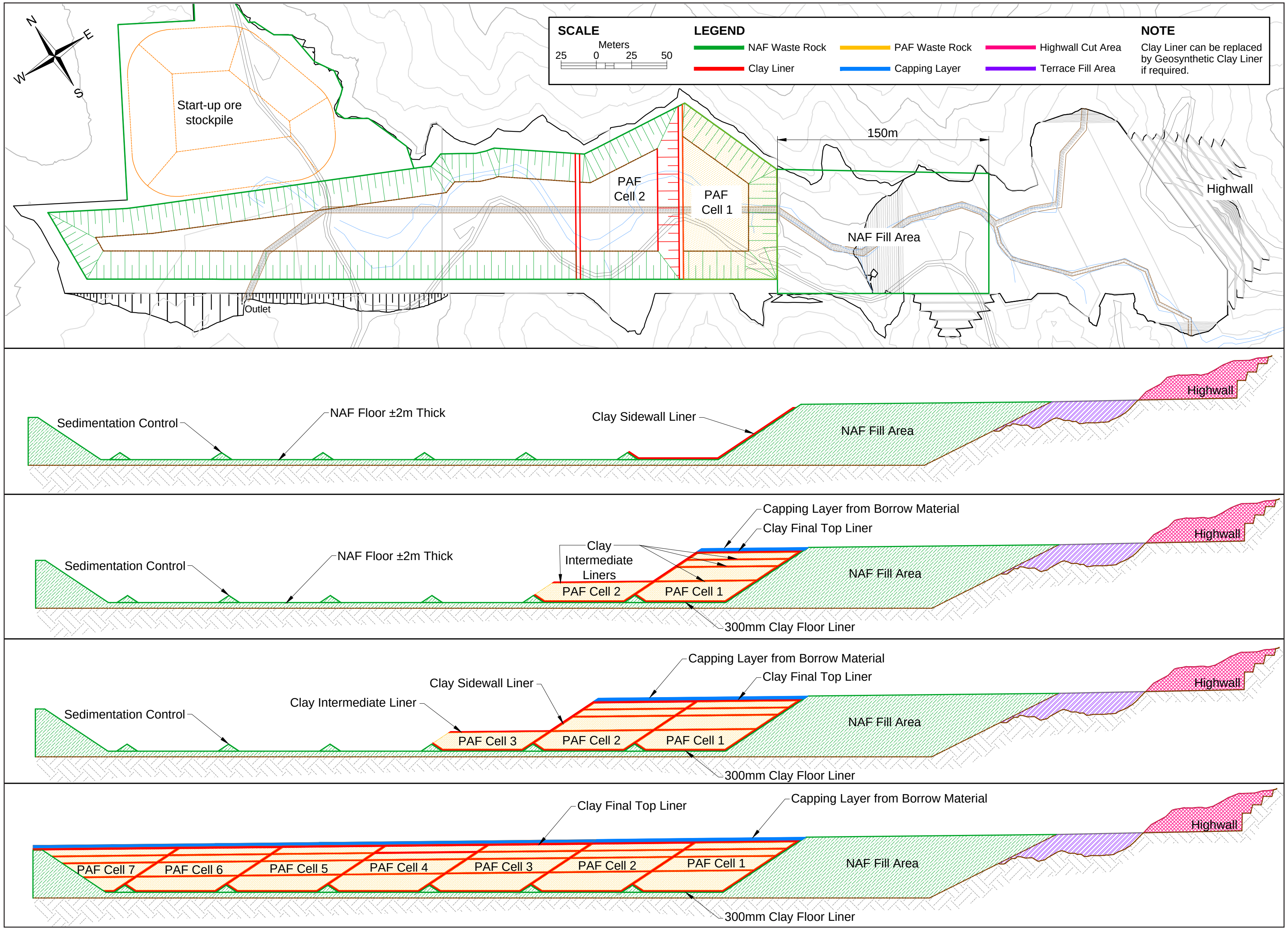
The basis of the design for these waste rock dumps is described further in the following sections.

6.7.2.1. Watut Declines Waste Rock Dump

The Watut Declines Waste Rock Dump, which is constrained by the Boganchong Creek valley in which it is proposed to be located, has been designed to accommodate waste material from underground development and surface earthworks. The facility will cover approximately 12ha of the Boganchong Creek valley and will be approximately 780m long and 140m wide (averaged), with a varying vertical height. The downstream end of the facility will not have a conventional waste rock dump toe but will abut the process plant terrace, forming one continuous footprint housing Project infrastructure. The Watut Declines Waste Rock Dump has a design capacity of 1.2Mt of PAF waste rock.

The NAF waste rock generated during decline development is proposed to initially be placed next to, and downstream of, the Watut Decline Portal Terrace, to create a NAF fill area above the portal terrace steel culvert underdrain (Figure 6.11). This 1m to 2m thick layer of compacted NAF waste with very low permeability (approximately $1x10^{-9}$m/s) will cover the valley floor underlying the waste rock dump.

As shown in Figure 6.11, PAF waste will then be placed within the NAF-lined cell and intermediate layers of low-permeability clay placed over the surface of the PAF waste at intervals during operation to limit the duration of exposure to air and water. Only one PAF cell is planned to be operational at any given time and each cell will be operational for a period of approximately eight weeks.



Source:
WGJV (Worley Parsons RSA Ltd): Golpu Stage 1 Project, Watut mine paf cell storyboard (Figure A)

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Wafi-Golpu Project

Diagram of waste rock dump cell construction

Figure No: 6.11

INDD Reference: 0520DD_10_GRA050.indd_3

Once a PAF cell reaches capacity, a cover of NAF material and compacted clay will be placed on top to cap the cell and the PAF waste disposal will progress to the next cell in the series. Given that the majority of the excavated material is expected to be PAF, encapsulation will involve sourcing of clay material and capping rock from quarries or borrow pits.

To prevent water ponding within the active cell receiving PAF waste, a gravity decant water system will direct water to a series of collection sumps for testing, treatment (if necessary) and discharge.

Routine monitoring of the waste rock dump cells during operations will be undertaken to allow early detection of seepage and AMD. Potentially contaminated runoff and seepage from the waste rock dump will be collected for testing and treatment (if necessary). This water will either be used to fulfil process plant water demands (during operations) or discharged to the downstream environment in the Lower Watut River.

6.7.2.2. Miapilli Waste Rock Dump

Waste rock from the Nambonga Decline will be stored within the Miapilli Waste Rock Dump located in the Yor Creek catchment. The Miapilli Waste Rock Dump will store approximately 0.86Mt of waste rock from the Nambonga and Watut declines, comprising mostly PAF waste rock (0.83Mt) plus a small amount of NAF waste rock (0.03Mt). Figure 6.12 shows the conceptual arrangement of the Miapilli Waste Rock Dump in plan and cross-section view.

The footprint of the waste rock dump will be approximately 5ha and will be constructed to a nominal height of 10m. The Miapilli Waste Rock Dump will be designed and constructed to appropriately manage PAF material in a manner consistent with that described for the Watut Waste Rock Dump and will include a drainage and leachate recovery system. The NAF material for construction of the base of the waste rock dump and for encapsulation will be sourced from borrow pits or quarries in the Project Area (see Figure 6.5).

The drainage and sediment control system for the Miapilli Waste Rock Dump will be designed to overflow to the environment in a controlled manner during a storm event. The seepage and runoff will be captured, treated if necessary to comply with permit conditions using a water treatment plant located at the Nambonga Decline Portal Terrace, and discharged to Nambonga Creek.

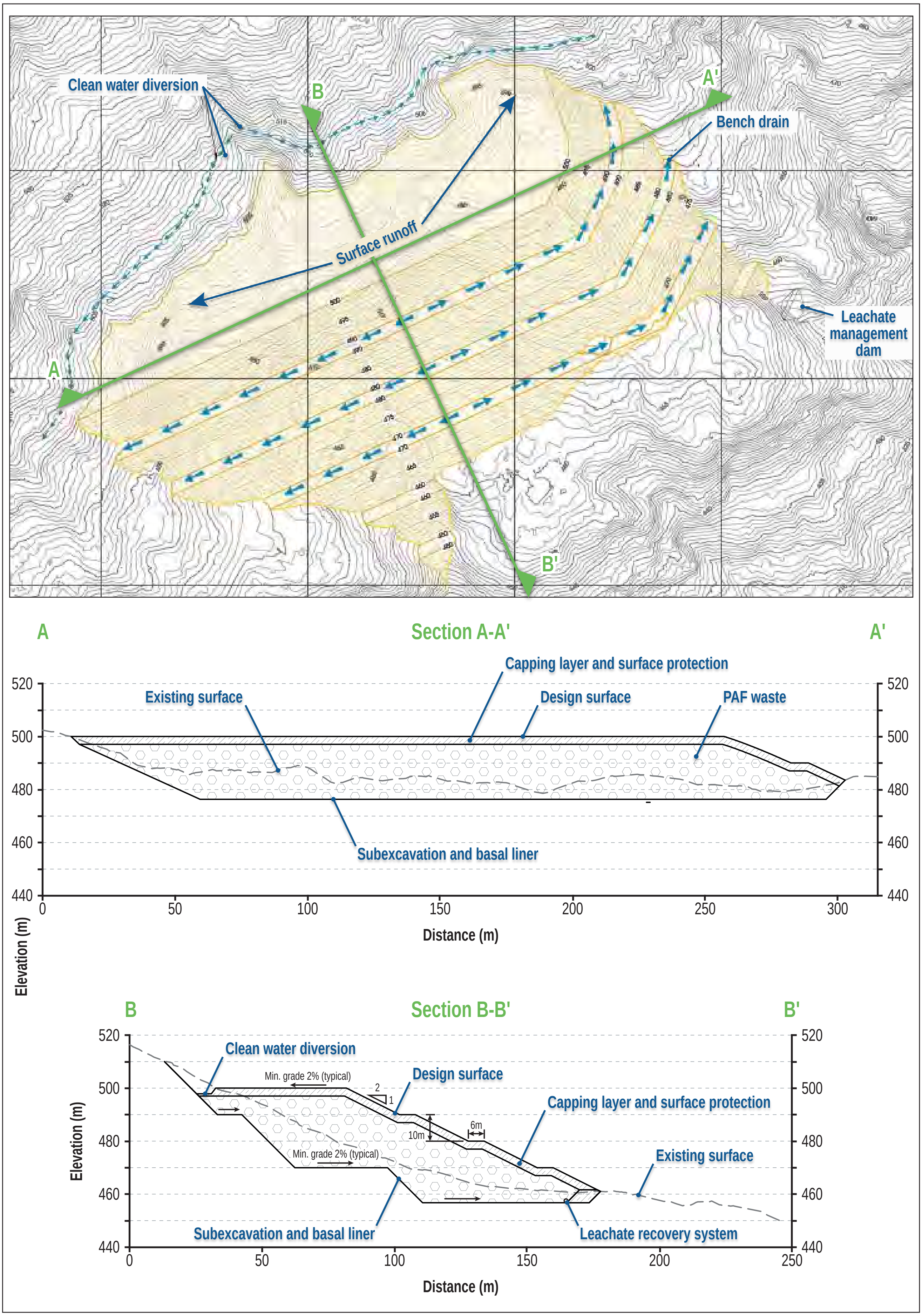
6.8. Watut Process Plant

Ore will be processed in the Watut Process Plant using conventional comminution (i.e., crushing and grinding) and flotation technology to produce a copper-gold concentrate slurry. This process is described below.

6.8.1. Ore Treatment

The proposed location for the Watut Process Plant for ore treatment is on the plant terrace.

In the ramp-up to full production during Years 1 and 2 of the operations phase, ore treatment will be undertaken in short-term ‘campaigns’ (e.g., seven days on, seven days off) due to the restricted land available for stockpile areas. Following ramp up, the Watut Process Plant is expected to operate 365 days per year, with the exception of scheduled and unscheduled shutdowns.



coffey A TETRA TECH COMPANY	Date: 26.04.2018 Project: 754-ENAUABTF100520DD File Name: 0520DD_10_F06.12_GRA	WAFI-GOLPU JOINT VENTURE Wafi-Golpu Project	Miapilli Waste Rock Dump conceptual design	Figure No: 6.12

The ore treatment process starts with the reclamation of crushed run of mine (ROM) ore from the coarse ore stockpile. The coarse ore will be ground in a semi-autogenous grinding mill and ball mills before passing through a metallurgical process separating the sulphidic minerals containing copper and gold from the rest of the ore by means of froth flotation. This process uses flotation reagents added to the slurry of milled ore to make the sulphide mineral particles adhere selectively to air bubbles, causing them to float to the surface, where they are skimmed off as concentrate, leaving the barren tailings behind.

Where necessary, flocculants will be used to remove suspended particles from the process water so the water can be recycled back through the plant. Flocculants, or flocculating agents, are chemicals that promote flocculation by causing colloids and other suspended particles in liquids to aggregate.

The ore processing flowsheet is summarised in Table 6.3.

Table 6.3: Watut Process Plant stages and descriptions

Stage	Description
Coarse ore storage and reclamation	Crushed ore is stored on an open-air coarse ore stockpile and reclaimed for recovery by underground reclaim feeders.
Grinding	Through a crushing and grinding process, coarse ore will be ground to a particle size of approximately 106 microns (µ).
Copper rougher flotation	The copper rougher circuit is the first step of flotation in recovering copper into a concentrate stream.
Jameson cell – first copper rougher concentrate cleaner flotation	This step upgrades the mineral concentrate through another flotation step, a device called a Jameson cell.
Copper concentrate regrind milling	A portion of the concentrate stream undergoes fine grinding to better liberate the copper minerals for further upgrading or concentration.
Copper three-stage cleaner flotation	The cleaner circuit aims to produce a higher-grade product (i.e., a higher copper concentration).
Copper scavenger flotation	This stage treats the cleaner circuit tails for a second time to recover any valuable material not already recovered.
Pyrite concentrate regrind milling	A portion of the pyrite concentrate stream undergoes fine grinding down to 30 microns to better liberate the gold-bearing pyrite.
Pyrite cleaner flotation	The cleaner circuit aims to produce a higher-grade product (i.e., a higher gold concentration).
Pyrite scavenger flotation	This flotation stage treats the cleaner circuit tails for a second pass at valuable material that may not have been recovered initially.
Concentrate thickening and long-distance pumping to the concentrate filtration plant	The product from the mine is a copper and gold concentrate. The concentrate slurry stream will be dewatered to 55% solids and pumped to the concentrate filtration plant at the Port Facilities Area.
Pumping tailings – terrestrial tailings pipeline to Outfall System	Tailings from the Watut Process Plant will be provided to the pump station from the tailings thickener and subsequently sent to the Outfall System via the terrestrial tailings pipeline.

The residue that remains after processing is known as tailings and its management is described further in Section 6.10.

6.8.2. Ore Treatment Reagents

The reagents used to treat the ore and their expected rates of consumption in the Watut Process Plant are shown in Table 6.4. Cyanide is not planned to be used in the processing of ore from the Golpu deposit because there is no plan to produce gold as a separate product (which would require cyanide as a processing reagent).

Table 6.4: Watut Process Plant approximate reagent consumption at 16.84Mtpa production rate

Name	Chemical Name	Purpose	Consumption at 100% Purity (tpa)
Frother	Alkyl aryl ester	Frother – Air bubble enhancer during flotation	470
Collector AP3894	Dialkyl thionocarbamate	Collectors – Used to treat the surface of targeted sulphide minerals so they become more hydrophobic and can be separated from non-desirable minerals	155
Collector A3418A	Dithiophosphate – aqueous		199
Collector Potassium Amyl Xanthate	PAX		433
Flocculant	Polyacrylamide, anionic	Flocculants - Promote flocculation and separation by causing colloids and other suspended particles in liquids to aggregate	280
Sodium Metabisulphite (SMBS)	SMBS	Depressants – Inhibit the flotation of pyrite during processing	2,890
Lime	Calcium oxide	pH modification - Improve process efficiency	21,670

6.8.3. Ore Stockpiles

6.8.3.1. Temporary Ore Stockpile

A temporary start-up ore stockpile is planned to store ore extracted during the development of the block cave extraction levels (Figure 6.6). It will be built on a purpose-built, low-permeability base, adjacent to the Watut Declines Waste Rock Dump, to stockpile material for processing until the Watut Process Plant commences operation. This ore will then be used in the commissioning process. Once reclaimed completely, the stockpile will be decommissioned.

6.8.3.2. Coarse Ore Stockpile

A coarse ore stockpile will be required to maintain a steady supply of ore for the Watut Process Plant and to minimise fluctuations in the availability of feed material. Crushed ore from underground will be conveyed to a single, conical, open stockpile with a live capacity of approximately 40,000t.

The stockpile will be located on a purpose-built compacted earth base constructed between the Watut Declines Portal Terrace and the process plant terrace. The majority of ore in the coarse ore stockpile will be stored there for an average of 18 hours. However, a proportion of the ore will remain within the stockpile for a longer period of time. The coarse ore stockpile is expected to be completely removed every eight months to allow access to the feeder tubs for inspection and maintenance.

6.9. Mine Water Management

The mine water management system has been designed to capture potentially contaminated water within the Mine Area during construction and operations, and manage, including treatment where necessary, this captured water for re-use or disposal. As a general principle, clean water will be diverted around surface works and, where practicable, water will be intercepted (by dewatering) before it can enter the block cave zone or, prevented from entry into the declines, by shotcreting or grouting. This is intended to minimise the volume of water requiring management during construction and operations.

6.9.1. Mine Water Management Overview

The Mine Area is located in a high rainfall and high runoff environment, averaging 2,836mm of rainfall per year. Block cave mining and the associated declines, ventilation shaft, block caves, rock subsidence zone and ore stockpile will increase the exposure of rock to both water and oxygen and, if acid forming, could lead to acidification of contacting water and dissolution of metals due to AMD.

The water management objectives are to contain fugitive sediments to levels consistent with the natural sediment regime and to prevent potentially contaminated contact water reaching downstream watercourses. This will be achieved by minimising the exposure of PAF materials to air and water and implementing a mine water management system to minimise AMD.

Figure 6.13 shows a schematic representation of the mine water management system for construction and operations.

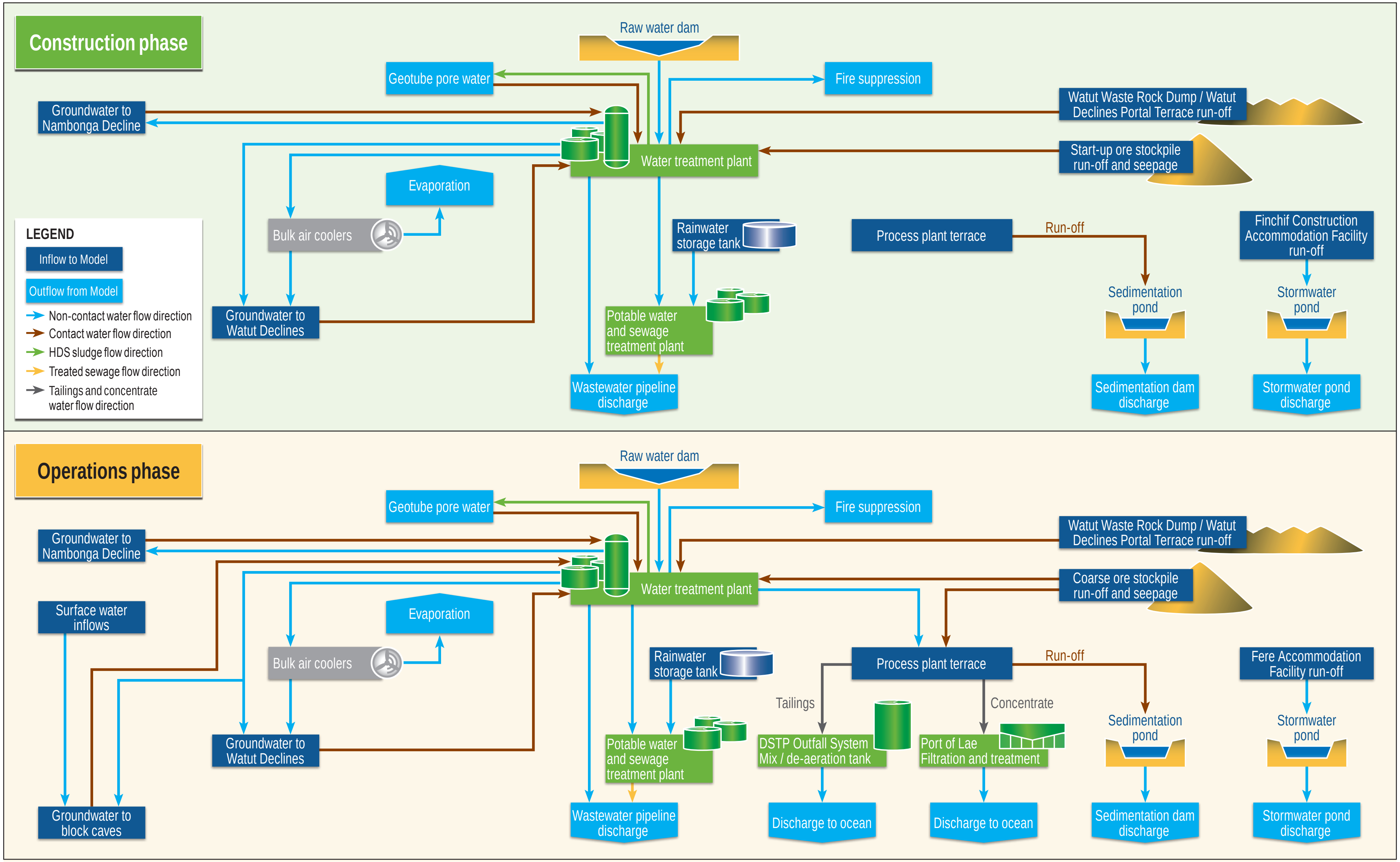
6.9.1.1. Construction

The water treatment plant, based on a system developed by Clean TeQ (2017), will be installed on the process plant terrace prior to development of the Watut Declines (see Figure 6.6). During construction, potentially contaminated mine waste water will be treated if necessary and discharged to the Watut River via the wastewater discharge pipeline (see Figure 1.2). This includes potentially contaminated water from:

- The Watut Declines
- The Watut Declines Waste Rock Dump, including any seepage
- Watut Declines Portal Terrace runoff
- Temporary ore stockpile runoff and seepage
- Runoff from geotubes (used to store residual sludge produced as a by-product of water treatment during construction)

At the Nambonga Decline area, a further water treatment plant will be available prior to decline development to treat, as required, water from the Nambonga Decline and from the Miapilli Waste Rock Dump. The high density sludge from this water treatement plant (containing gypsum and metal hydroxides) will be stored and dried in geotubes and then buried within the Miapilli Waste Rock Dump. Any seepage water from the Miapilli Waste Rock Dump requiring treatment will be pumped via a HDPE pipeline to this water treatment plant and discharged to Nambonga Creek.

Sewage will be treated at a sewage treatment plant on the process plant terrace with the treated effluent reporting to the Watut River via the wastewater discharge pipeline. Residue generated through the sewage treatment process will be buried in a dedicated cell in the waste management facility (see Figure 1.2).



Source:
Piteau Associates, 3695TM04v4_SiteWideWaterBalance, Figure 2-1 and 2-2

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WAFI-GOLPU JOINT VENTURE

Wafi-Golpu Project

Mine water management schematic for construction and operations

Figure No: 6.13

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Runoff from the surface construction activities (i.e., from the process plant terrace and the accommodation camp) will flow to sedimentation or storm water ponds before discharging to the environment.

During construction, sedimentation ponds will be designed to accommodate flows up to a 24 hour 2-year average recurrence interval (ARI) and be structurally sound in events up to 100-year ARI. Other sediment controls (e.g., channels and check dams) will have capacity for a 10-year ARI flow.

6.9.1.2. Operations

During operations, treated mine waste water (from declines, block caves, runoff and seepage and sewage effluent) will be used as the primary water source for ore processing and as the transport media for concentrate and tailings. Given that the process water demand exceeds the volume of waste for the majority of the time during operations (see Section 6.9.2), it is predicted that there will be limited periods during operations in which mine waste water will require discharge to the Watut River (see Appendix V, Site-wide Water and Mass Balance Modelling).

Sludge generated from water treatment will report directly to the process plant during operations. Runoff and seepage from the coarse ore stockpile will be used directly in the process plant without treatment.

During operations, surface water management structures, such as sedimentation ponds, are designed for one in 25-year rainfall events. Major storm water structures, such as the terrace storm water bypass system and the underdrain installed to divert water originating from the headwaters of Boganchong Creek, will be designed for a one in 50-year storm event (discussed further in Section 6.9.4.1). Water originating from the Watut Declines portal and plant terraces, including the coarse ore stockpile area, will require sediment removal and attenuation and testing and treatment before being released to the environment, or before it may be harvested for use in the process plant.

A raw water dam will allow for the local storage of raw water and for the harvesting of runoff water from the site.

Bunded areas around hazardous materials storage facilities will be designed to contain spills and storm water during a one in 200-year storm event. Water treatment in these areas will include grease and oil traps.

The surface water management proposed for key facilities are described in further detail in Section 6.9.4.

6.9.1.3. Closure

During decommissioning and post-closure, water will be directed to the underground workings to accelerate filling of the block caves and declines to reduce the period of exposure of sulphidic material in the block cave and decline walls. Additional water may be abstracted from the Watut River if required. This, in conjunction with natural flows and recharge, will result in the development of a subsidence zone lake, for which the water and load balance modelling results and management approach is discussed further in Section 6.21 and presented in full as Appendix X, Assessment of Closure Conditions and Water Management Options for the Wafi-Golpu Block Cave and Subsidence Zone.

6.9.2. Water Demand and Supply

Water is required for a range of mine activities, the majority of which relate to those shown in Table 6.5.

Table 6.5: Estimated water demand (m^3/h)

Project Year	Year 1 construction	Year 2 to Year 5 construction	Early operations (pre-cave breakthrough at surface)	Late Operations (post-cave breakthrough at surface)
Construction water	1	1	0.1	0.1
Bulk air cooling water	4	22	32	35
Mine service water	10	45	30	30
Potable water	4	10	10	10
Fire water	36	200	200	200
Process plant make-up water	0	0	600	1,365
Total water	**55**	**278**	**872**	**1,640**

Water produced during construction will be reused where possible (e.g., in dust suppression activities or for shaft drilling water supply). Of the treated water produced during construction (peak of around 890m^3/hr), between 10% to 50% will be re-used. The balance will be discharged to the Watut River via the wastewater discharge pipeline.

The total demand for water will be typically around 1,600m^3/hr during operations. Reductions in demand occur from Year 6 to Year 7 of operations and Year 13 to Year 15 as mining transitions from BC44 to 42 and BC42 to 40, respectively. Treated water and runoff water from the process plant and stockpile areas will be used to supply the water demands, where possible. For the majority of operations, 100% of the treated water is likely to contribute to water supply.

Additional site water demands, i.e., those not fulfilled through treated water, will be supplemented using Lower Watut River water. Water from the Lower Watut River will conservatively provide around 50% of the total demand during operations. This volume of water would represent less than 1% of the flow rate of the Lower Watut River, even during the dry season.

6.9.3. Underground Infrastructure

The groundwater inflows predicted to enter the underground mine have been modelled and the predicted changes in inflows over time reflect the various stages of mine construction and operation as shown in Figure 6.14.

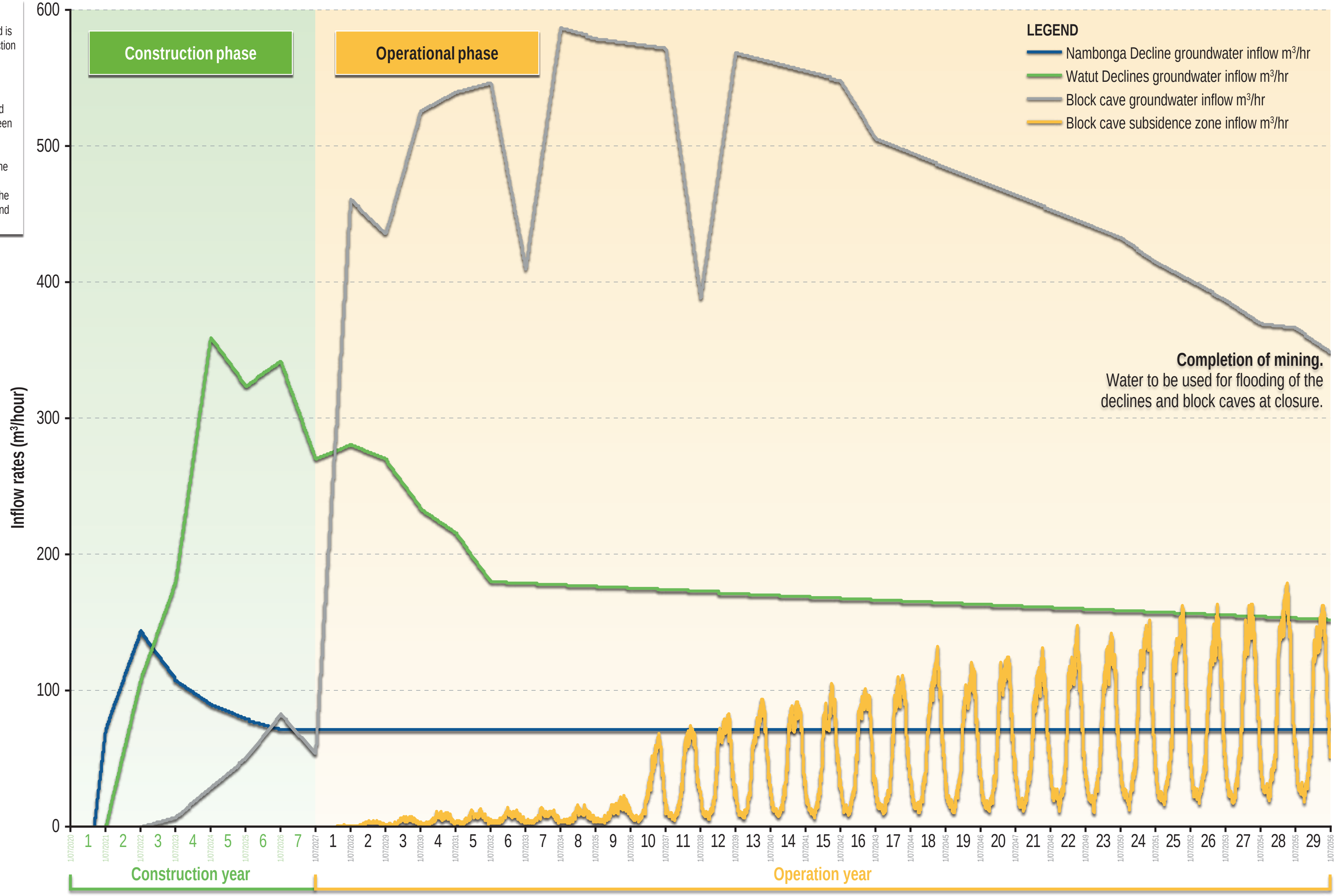
Numerical groundwater modelling (Appendix F, Groundwater Management and Modelling of Inflows to Golpu Underground Mine) predicts groundwater inflows to the mine will commence at the start of the Nambonga Decline development, peaking at 144m^3/hr in the early years of construction. Groundwater inflows from the Watut Declines are predicted to peak approximately two years later at 360m^3/hr. Inflows from the Nambonga and Watut declines are predicted to reach a steady state in early operations at approximately 70m^3/hr and 180m^3/hr, respectively. The block caves are predicted to produce the greatest proportion of groundwater inflow, peaking at close to 600m^3/hr around Year 8 of operations. Surface water inflows through the subsidence zone are predicted to become a more predominant contributor around the middle of operations (i.e., from Year 15), with the seasonal variations apparent in Figure 6.14.

Groundwater inflows to the ventilation shaft are predicted to be negligible (estimated to be less than 0.002m^3/s) as the ventilation shaft is planned to be lined with concrete.

Notes:

1. The seven year construction period is related to a previous Project construction schedule prior to refinement to a five year construction schedule.

2. While the construction of the Nambonga Decline Portal is proposed to be developed approximately eighteen months to two years earlier than the Watut Declines, in the model, the development of the Nambonga Decline Portal has been assumed to occur approximately three months prior to the development of the Watut Declines and subsequent block cave development.



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WAFI-GOLPU JOINT VENTURE

Wafi-Golpu Project

Estimated median inflows to the underground workings during construction and operations

Figure No: 6.14

To remove water inflows from the underground workings, a series of sumps and pump stations will be established progressively during decline development, forming a cascade pumping system that will operate for the life of the Project. Dewatering of the underground operations will also involve the establishment of surface dewatering bores and horizontal drains. Dewatering infrastructure is referred to as the main declines cascade dewatering system and block cave's high lift dewatering system. The other dewatering systems including the interconnecting declines and sumps are referred to as ancillary dewatering systems. The main declines system has dewatering capacity of 360m^3/hr and the block cave systems individually have a dewatering capacity of 648m^3/hr. This excludes emergency dewatering capacity.

Groundwater modelling predicts that by the end of mine life the groundwater drawdown will reach a maximum depth of 800m and extend 1,400m southwest, 1,250m southeast and 1,300m northeast of the mine (Appendix F, Groundwater Management and Modelling of Inflows to Golpu Underground Mine).

6.9.4. Surface Infrastructure

It is proposed that sedimentation ponds will be installed downstream of key Project infrastructure, prior to construction, to capture sediment-laden water. Construction of sedimentation ponds in Boganchong Creek downstream of the Watut Declines portal and process plant terraces' facilities will limit sediment reporting to downstream reaches of this creek.

The sedimentation ponds will generally comprise an embankment wall of rock, earth and concrete against which the sediment will accumulate. Sediment will be removed on a periodic basis using an extended boom excavator from adjoining roads and will be placed in the landfill area within the waste management facility or the waste rock dump. Water will drain into downstream watercourses via an overflow spillway.

Sediment control infrastructure, such as ponds will be excavated regularly to maintain their efficiency, with removed sediments deposited within the waste management facility or the waste rock dump.

A raw water dam (with a nominal holding capacity of 40,000m^3) will act as a holding facility for storage of raw water and for the harvesting of runoff water. The dam will be located in a steep sided valley downstream of the plant. The wall is 30m high from the lowest toe point to the crest, with an average height of 20m.

Access roads, facility sites and supporting infrastructure will be designed to maintain adequate surface water flows and avoid redirection of stream flows, where practicable. Stormwater drainage and bunding systems will be designed and constructed capable of withstanding a 1 in 200-year storm event.

The general arrangement of surface water management infrastructure is shown in Figure 6.15.

6.9.4.1. Watut Declines Portal Terrace and Watut Waste Rock Dump

The proposed Watut Declines Portal Terrace will be located on top of Boganchong Creek. Prior to any construction works, a sedimentation pond will be constructed downstream of the portal terrace that will capture fugitive sediments from the construction areas.

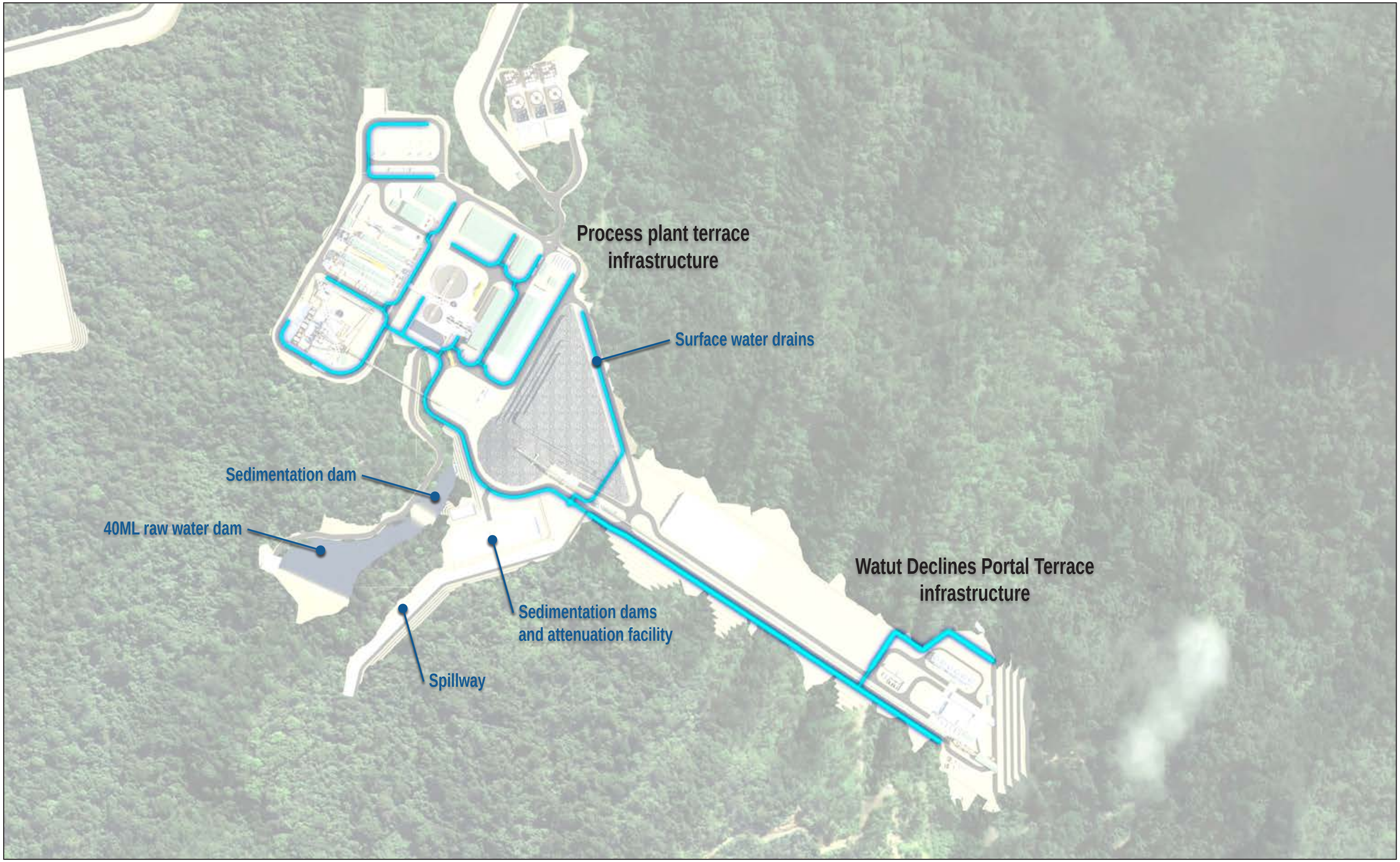

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Figure No: 6.15

During the construction phase, a subterreanean underdrain system (comprising steel pipe culverts and designed for a 1 in 50-year storm event) will be installed beneath the portal terrace to divert clean water from the natural catchments (i.e., upper Boganchong Creek) to a spillway that flows to Boganchong Creek downstream of the raw water dam. Blockages of the underdrain culvert by large debris will be restricted by the positioning of screening and gabion boxes and walls at the underdrain culvert entrances to act as filter screen. The discharge energy of the flows entering the underdrain will be reduced by using gabion mattresses and gabion baffles at the exit to prevent erosion prior to discharging into the sedimentation pond.

As the Watut Declines Portal Terrace will remain unpaved throughout the duration of the Project, sediment-laden runoff will flow to the sedimentation dam and attenuation facility (see Figure 6.15). The twin sedimentation dams are designed for a 2-year ARI event. Once construction of the Watut Declines Portal Terrace has been completed, concrete-lined surface drains designed to capture a 1 in 100-yearstorm event will capture flows from the high wall, side walls and sides of the valley for all rainfall events as well as overflows that exceed the capacity of the underdrain. This water will also report to the two sedimentation dams downstream of the portal terrace.

The sedimentation pond in Boganchong Creek will capture runoff from the process plant terrace.

As described in Section 6.7.2, the Watut Decline Waste Rock Dump below the portal terrace will store NAF and PAF waste rock generated from the development of the Watut Declines. A 1 to 2m thick layer of compacted NAF waste (with very low permeability) will be placed on top of the steel underdrain system and will cover the valley floor underlying the waste rock dump. To prevent water ponding within the active cell receiving PAF waste, and to capture potentially contaminated seepage and runoff, a gravity decant water system will flow to a series of collection sumps for testing and treatment (if necessary). This water will either be used to supply water for the Project or be discharged to the Lower Watut River.

Workshops, diesel and oil stores and wash bays are designed to contain any stormwater and be pumped to suitable treatment plants, such as the mine water treatment facility and localised grease and oil separators.

6.9.4.2. Nambonga Decline Portal Terrace and Miapilli Waste Rock Dump

The Nambonga Decline Portal Terrace is located approximately 5m above Nambonga Creek. The approach to the portal will be within a reinforced tunnel abutting the high wall and retaining walls along a known landslip zone. The reinforced tunnel will protect the portal entrance from possible future landslides. Detailed information on sedimentation ponds and erosion and sediment control structure siting will be considered during the detailed design phase.

6.9.4.3. Process Plant Terrace and Ore Stockpiles

The process plant terrace will be located on top of a hill. Runoff from the process plant terrace will be captured using concrete lined drainage channels, which will be constructed along each of the process plant terrace's roads and will be channelled to the southeast corner of the lower terrace and discharged into the sedimentation pond located in Boganchong Creek.

Once block cave development commences, ore will be stored in the temporary ore start-up stockpile (prior to process plant production commencing) followed by storage at the coarse ore stockpile, both located on the process plant terrace (see Figure 6.4). The large majority of ore is PAF and the key water management issue for these ore stockpiles will be to capture and manage the potentially acidic drainage. Rainfall will infiltrate the stored ore before seeping from the toe of the stockpiles, which is expected to generate acid. Runoff and seepage water from the ore stockpiles will be collected via a gravity decant water system, flowing to a series of collection sumps for testing, treatment (if required) and used for water supply or discharged to the Lower Watut River.

6.9.5. Wastewater Treatment

6.9.5.1. Mine Wastewater

The majority of ore and waste rock is likely to be PAF and as mining progresses and the zone of subsidence increases, mine water quality is expected to deteriorate and become acidic with elevated concentrations of sulphate and dissolved metals, particularly zinc, copper, iron and manganese. Therefore, water from the mine workings, as well as seepage and runoff from the waste rock dumps, is expected to be unsuitable for direct discharge and likely to require treatment.

As described above and shown in Figure 6.13, water requiring treatment is most likely to originate from:

- The Watut and Nambonga declines
- Waste rock dumps and seepage
- Runoff from portal terraces
- Stockpile runoff and seepage
- Runoff from geotube consolidation water

The water treatment plant will be located north of the process plant terrace and adjacent to the southern end of the Infrastructure Corridor. The feed to the water treatment plant and the volumes of treated water discharged to the Lower Watut River during construction and operations are shown in Figure 6.16.

The water treatment plant is a modular design, allowing equipment modules to be added/removed as the mine water profile changes. One module of the water treatment plant is shown in Figure 6.17.

As described in Section 6.9.1, a further water treatment plant at the Nambonga Decline area will be available prior to the commencement of significant decline development to treat water from the Nambonga Decline and from the Miapilli Waste Rock Dump, as required.

Clean TeQ (2017) describes the capability and performance of the treatment facilities. Treatment will be completed (as required) by a high density sludge treatment process using lime precipitation to reduce metals concentrations. The high density sludge containing gypsum and metal hydroxides will be stored in geotubes on the Watut Declines Portal Terrace until such time as the Watut Process Plant becomes operational, at which stage sludge will be directed to the plant for metal recovery and disposal.

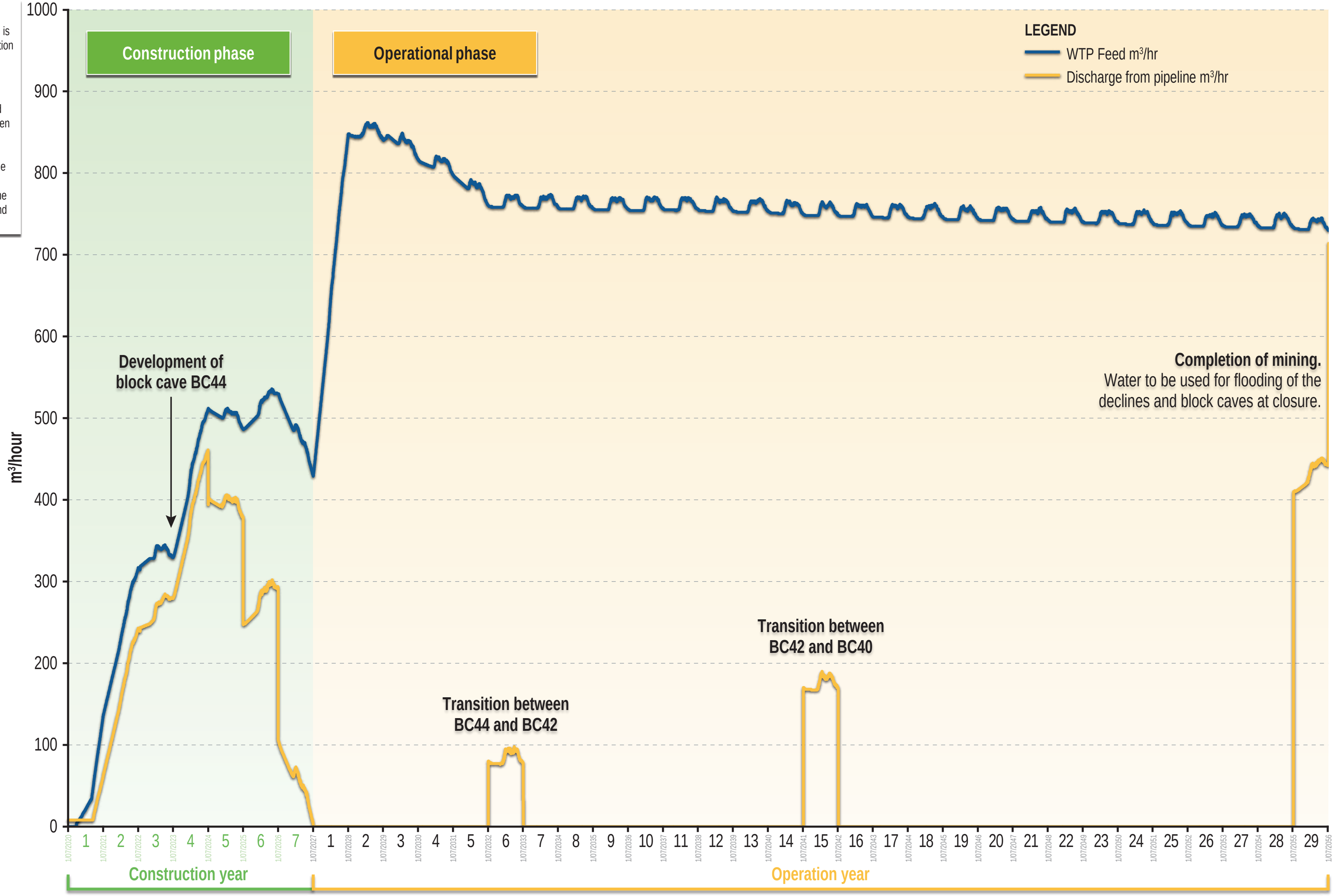
An estimated fifty percent of the overflow from the high-density sludge clarifier is proposed to be sent to the DeSALx unit where calcium and sulphate are both reduced. The DeSALx® system uses strong acid cation and weak based anion resins, regenerated with sulphuric acid and hydrated lime respectively. When mixed back in with the remaining 50% of overflow a treated water sulphate target of <800mg/L is achieved. Spent regeneration solutions will be recycled to the high-density sludge unit to provide a zero liquid discharge process.

High-recovery reverse osmosis (RO) will be installed on a portion of the DeSALx® treated water stream to supplement on-site potable water requirements, with water sourced from either the Lower Watut River or mine dewatering.

Notes:

1. The seven year construction period is related to a previous Project construction schedule prior to refinement to a five year construction schedule.

2. While the construction of the Nambonga Decline Portal is proposed to be developed approximately eighteen months to two years earlier than the Watut Declines, in the model, the development of the Nambonga Decline Portal has been assumed to occur approximately three months prior to the development of the Watut Declines and subsequent block cave development.



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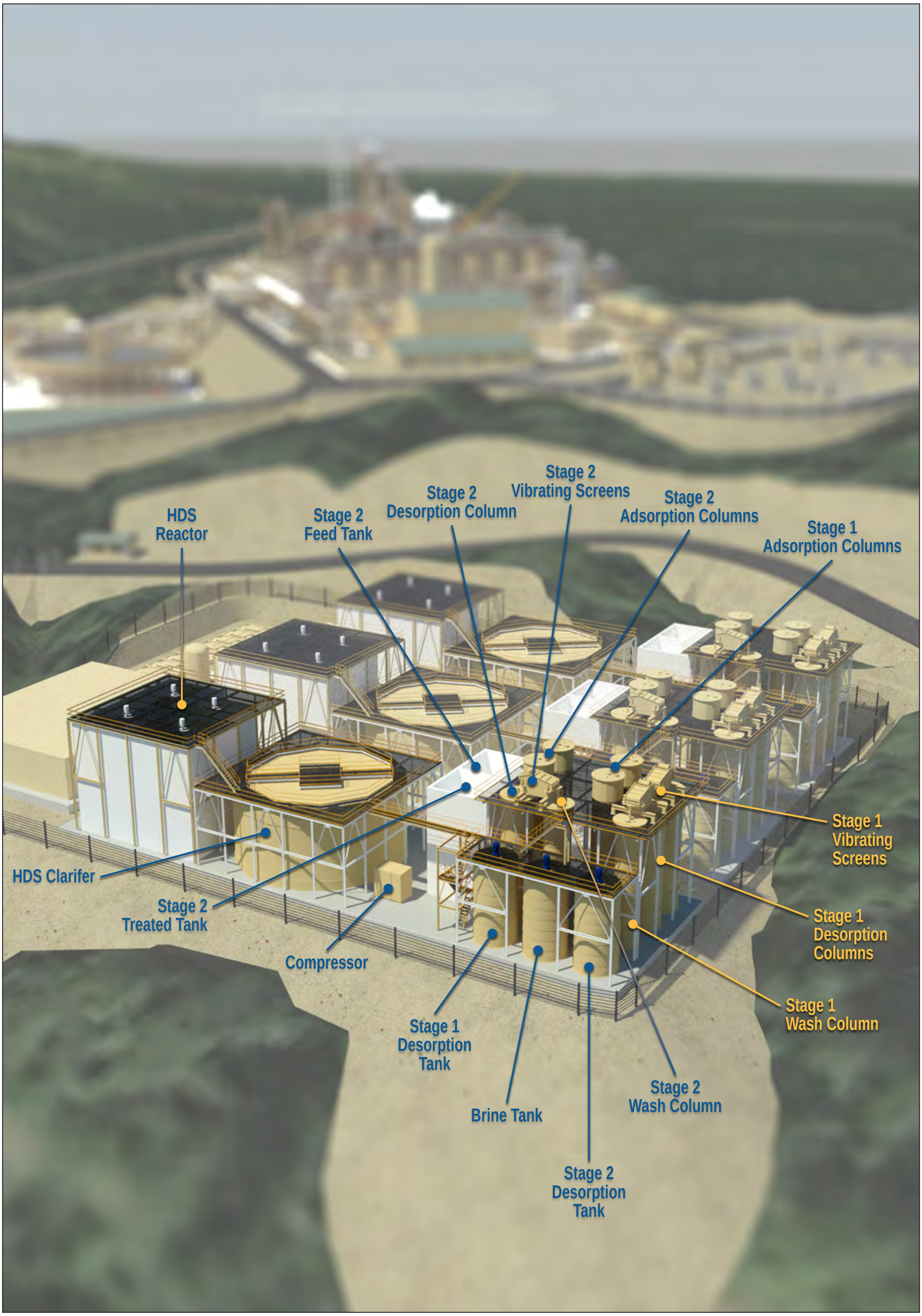
WAFI-GOLPU JOINT VENTURE

Wafi-Golpu Project

Water treatment plant feed and treated water discharge to the Watut River during construction and operations

Figure No: 6.16



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Synthetic leachate was prepared to simulate the mine waste water for the testwork and water treatment capability, and the results are presented in Clean TeQ (2017). The water treatment rates and corresponding nominal treatment plant sizes are presented in Table 6.6.

Table 6.6: Water management LOM treatment requirements

Project Year	Phase	Maximum treatment required (L/s)	Treatment plant position	Treatment plant size (ML/day)
Year 1 construction	Surface construction	122	Not applicable. Solids removal only	Sedimentation Ponds
Year 2 to Year 5 construction	Declines construction	210	Watut Process Plant terrace and Nambonga Decline Portal Terrace	HDS = 24 DeSALx = 12
Early operations (pre-cave breakthrough at surface)	Production and processing	260	Watut Process Plant terrace	HDS = 24 DeSALx = 12
Late Operations (post-cave breakthrough at surface)	Production and processing	440	Watut Process Plant terrace	HDS = 40 DeSALx = 20

6.9.5.2. Sewage Treatment

Sewage will be treated at a sewage treatment plant on the process plant terrace. The sewage treatment plant will provide treatment for approximately 1,400 people at a maximum effluent flow estimated at 200L per person per day. The treated effluent will report to the Lower Watut River from the wastewater discharge pipeline during the construction phase.

During operations, treated effluent will be directed to the process water tank. Sewage treatment plant solids will be buried in a dedicated cell in the waste management facility.

Sewage treatment will be designed to meet the requirements for Class A Recycled Water as defined by the Australian National Guidelines on Water Recycling (2005), with the exception of treatment for biological oxygen demand, which will be designed to meet the PNG Draft Environmental Guideline for Sewage Treatment and Disposal (20mg/L) (DEC, 2009). The nominal sewage effluent quality discharge limits for the Project are listed in Table 6.7.

Table 6.7: Sewage plant predicted maximum discharge effluent limits

Parameter	Unit	Value
Maximum biological oxygen demand	mg/L	20
pH range	s.u.	6.5 – 8.5
Maximum turbidity	NTU*	5
Maximum total suspended solids (TSS)	mg/L	25
Maximum total nitrogen	mg/L	10
Maximum total phosphorus	mg/L	3
Maximum total ammonia	mg/L	4
Minimum dissolved oxygen	mg/L	2
Escherichia coli bacteria (E. coli)	cfu**/100mL	<10

* NTU: Nephelometric Turbidity Units
** cfu: Colony-Forming Units

6.9.5.3. Wastewater Discharge

Treated wastewater (mine water and sewage effluent) will be discharged via the wastewater discharge pipeline to the Lower Watut River with the outlet located 0.9km west of Wongkins Village (refer to Figure 1.2).

The wastewater discharge pipeline will consist of a single, buried HDPE pipe that will run adjacent to the supporting service track. The pipe terminus will be submerged below the low flow level of the Lower Watut River.

6.9.6. Block Cave and Subsidence Zone Lake (Post-Closure)

Approximately 38 months after the start of block caving (as estimated from numerical modelling), a subsidence zone is predicted to start to form on the ground surface above the orebody. Following closure, groundwater levels within the block cave and subsidence zone will rise due to: groundwater inflow along the hydraulic gradient towards the block caves; surface catchment runoff and infiltration; and direct precipitation into the subsidence zone. This will be accelerated by pumping water from the Lower Watut River as mentioned below. This water inflow will over time form a lake within the subsidence zone at the surface. Hydraulic plugs will be installed at the Watut Declines portal to prevent water from the full block caves perpetually spilling from the portal entrances.

Infiltration of water from the subsidence zone lake to the underlying material, which hosts epithermal mineralisation with high acid-forming potential, is likely to result in poor water quality (low pH and elevated metals concentrations) within the cave voids. Key to the water quality within the voids will be the rate of inundation and time-frame for complete flooding, which will determine the exposure of sulphidic material in the cave walls which will continue to generate acid over time with subsequent flushing of the solutes into the emergent groundwater.

To reduce the time-frame for complete flooding, the block cave will be flooded by pumping from the Lower Watut River at a nominal rate of 500L/s. Modelling undertaken by Piteau (Appendix X, Assessment of Closure Conditions and Water Management Options for the Wafi-Golpu Block Cave and Subsidence Zone) estimated that inundation of the block caves (to 250mASL) will occur after 4 years. This compares to approximately 55 years that are estimated for natural filling (i.e., without pumping). Piteau estimates that it will take and a further 39 years to fill to the crater lip level of 450mASL. Following this, it is predicted that a steady state decant from the subsidence zone lake will occur at rates of 10 to 25L/s.

To maintain a nominal pH of 7, concurrent addition of a hydrated lime ($Ca(OH)_2$) slurry at a nominal rate of 3g/L during the filling of the block cave is proposed. This is predicted to offer significant benefits to the water quality of the inundated cave zone, both in terms of pH and metals.

Assuming full mixing, the subsidence zone lake water quality is projected to improve progressively during the period of flooding of the lake. By the time of initial discharge to the surface water drainage network, pH levels of around 5 are anticipated, with sulphate levels of no more than a few hundred mg/L and concentrations of iron, manganese, copper and aluminium in the 1 to 2mg/L range. Discharges from the lake would be expected to be acidic with elevated concentrations of metals and metalloids, and are expected to exceed PNG ER Criteria and ANZECC/ARMCANZ guidelines for ambient water quality.

Prediction of the quality of water that will accumulate in, and ultimately discharge from, the subsidence zone lake is complex. Notwithstanding this uncertainty, discharge of water from the lake may require treatment to meet regulatory water quality criteria at the agreed compliance point for an unknown period.

6.10. Tailings Management

Tailings are a combination of the solid material remaining after the recoverable metals and minerals have been extracted from mined ore, and any remaining process water. The proposed mine is predicted to generate approximately 360Mt of tailings over the life of the Project, which will need to be managed in a low risk, economic and environmentally secure manner.

6.10.1. Overview

The WGJV, through the course of its concept, pre-feasibility and feasibility study programs, has assessed a number of options for tailings management. This has included pre-feasibility and feasibility-level investigations into the following options for tailings management for the Project:

- On-land storage in a tailings storage facility (TSF)
- Dry-stacking
- Deep sea tailings placement (DSTP)

Chapter 7, Assessment of Alternatives, provides a detailed discussion of the alternatives and includes a comparison of the tailings management options and the basis for selection of a preferred option. The detailed assessments undertaken of different on-land tailings management options are discussed in Section 7.3.4.3. The only other option considered for tailings management was deep sea tailing placement (DSTP).

Section 7.3.4.6 concluded that of all the options considered, generally, it is the DSTP option that has the lowest level of risk, severity of consequence or level of constraint, particularly relating to the post-closure phase. Based on a desire to minimise impacts on the biophysical and social environment and cultural heritage and adopt the option with the lowest construction, operational and post closure risks, WGJV has decided to adopt DSTP as the preferred tailing management option for the Project.

Approximately 360Mt of tailings will be produced from BC 44, BC 42 and BC 40. A summary chart showing the forecast tailings production is shown in Figure 6.8, where the timings shown are indicative only to illustrate the general tailings production profile.

As discussed in Section 6.8, development of the Project will involve processing ore via a conventional copper-gold flotation circuit. The geochemical and physical characterisation of tailings is detailed in appendices L and M respectively, and is summarised below.

The CSIRO conducted geochemical and ecotoxicological characterisation of two tailings samples produced from a pilot flotation testwork program in October 2016. The two samples comprised approximate porphyry and metasediment compositions of 90:10 and 25:75, representing the likely extremes of tailing characteristics that will be produced during the LOM. The tailings liquor samples were both pH neutral.

The concentrations of total recoverable metals in the tailings samples exceeded the Sediment Quality Guideline Value (SQGV) for chromium, copper, nickel and zinc. Similarly, the concentrations of potentially bioavailable metals in the tailing samples exceeded the SQGV for copper, nickel and zinc.

Particle size analysis of the two tailings samples was also undertaken by the CSIRO. Tailings sample 1 (representing the porphyry to metasediment ratio of 90:10) has a higher content of fine-grained solids (63% of solids are less than 20μm particle size diameter). Tailings sample 2 (representing the porphyry to metasediment ratio of 25:75) has a lower content of fine-grained solids (42.3% of solids less than 20μm particle size diameter). The Tailings 1 sample comprises very fine sediments with 87% being classified as clay and silts.

The geochemical and ecotoxicological testwork program results regarding the potential long-term effects of metals released from the tailings in the deep ocean marine environment, and the physical fate and behaviour of the discharged tailings, are presented in Chapter 17, Offshore Marine Environment Impact Assessment.

6.10.2. Deep Sea Tailings Placement

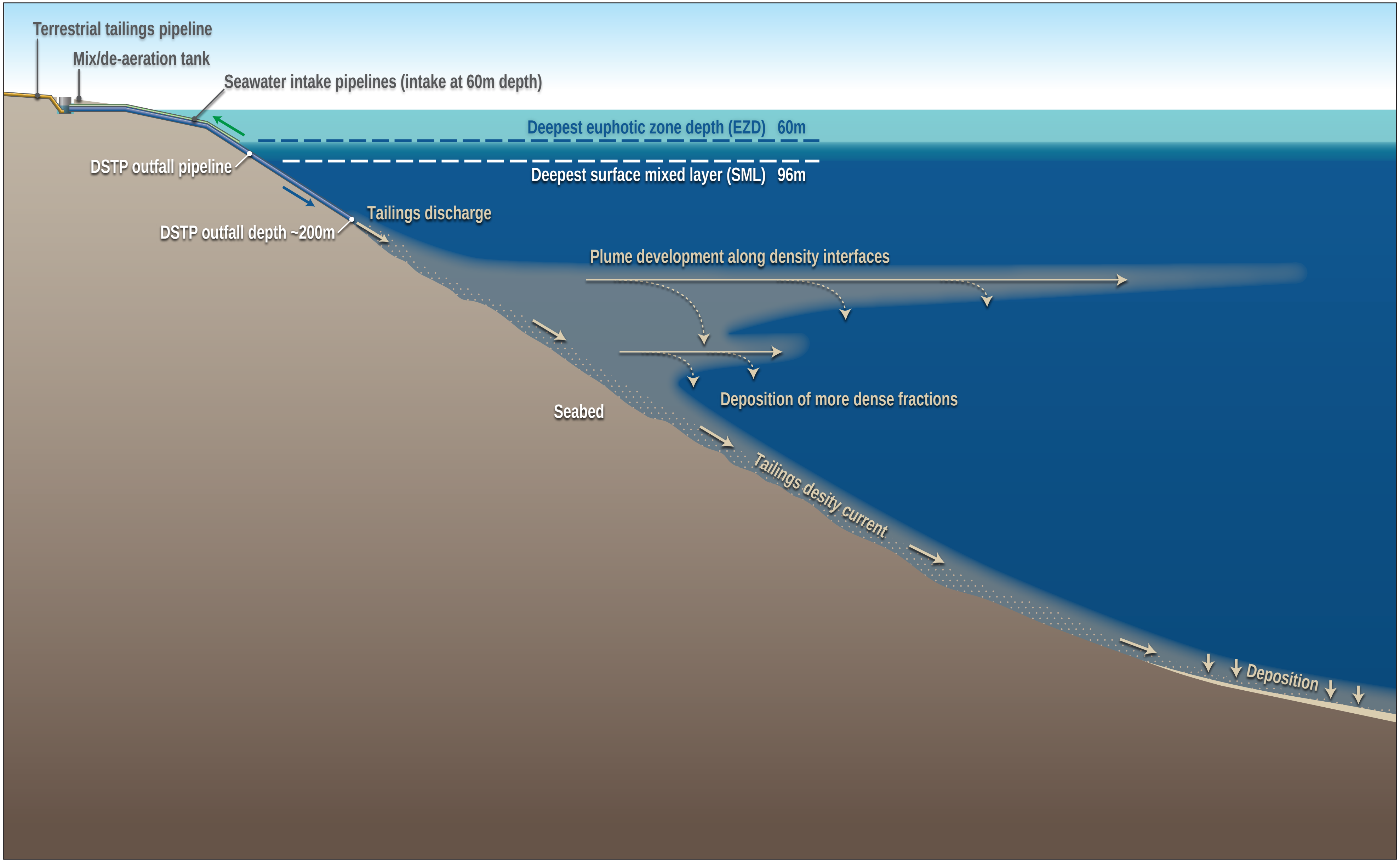
Deep sea tailings placement is proposed for all tailings produced. It involves the discharge of tailings slurry from an outfall pipeline terminus located approximately 200m below the ocean surface. On exiting the outfall pipe, the tailings flow down the sloping seafloor as a density current, with the ultimate deposition of the tailings solids on the deep-ocean floor. Figure 6.18 provides a conceptual representation of this tailings density current.

In 2010, the Conservation and Environment Protection Authority (then Department of Environment and Conservation), in collaboration with the Mineral Resources Authority, commissioned the Scottish Association for Marine Sciences to prepare a set of Draft General Guidelines for DSTP in PNG (SAMS, 2010). The completion of the engineering design for the DSTP system for the Project and the environmental investigations, which informed design were undertaken in accordance with the Draft General Guidelines for DSTP in PNG, to the maximum practicable extent. Attachment 1 provides a cross-reference of how these guidelines are addressed in the EIS, with further discussion in Chapter 17, Offshore Marine Environment Impact Assessment.

The key principles of successful DSTP (aligned with SAMS, 2010) include:

- Selection of an outfall site where the seafloor slope is sufficiently steep to ensure the tailing solids will not accumulate and block the DSTP outfall pipelines and where the seafloor slope continues into deep water
- Selection of a discharge depth that is deep enough to be below the:
  - Near-surface biologically productive layer (known as the euphotic zone) where light penetration from the surface allows photosynthesis to take place
  - Deepest measured surface mixed layer (i.e., the uppermost part of the ocean water column that is kept well mixed by the turbulent action of wind and waves)
  - The base of upwelling (if any), whereby wind-driven motion of dense, cooler and usually nutrient-rich water towards the open surface, replaces the warmer, usually nutrient-depleted surface water
- Provision of adequate de-aeration of the tailing slurry prior to discharge to avoid transportation of the tailings to the surface by air bubbles
- Ensuring that the tailings slurry has a higher density than the receiving ocean water so that a density current will form and flow down the sloping seafloor
- Ensuring there are no seabed features to prevent the installation of the DSTP outfall pipelines

These principles have been met to the maximum practicable extent in the design of the DSTP system, with further information provided in chapters 7, 10, 11, 16 and 17, and appendices K and V, of this EIS.



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Conceptual representation of tailings density current

Figure No: 6.18

6.10.2.1. Design of the DSTP System

Proposed infrastructure for management of tailings through DSTP comprises:

- Tailings pump station located at the process plant terrace in the Mine Area
- Terrestrial tailings pipeline 103km long to transport tailings slurry from the tailings pump station in the Mine Area to the Outfall System (discussed in Section 6.10)
- Tailings Outfall System comprising (Figure 6.19):
  - A mix/de-aeration tank (14m diameter, 15m high) located in a dry moat 120m inland from the shore
  - Two HDPE seawater intake pipelines (outside diameter of 1,000mm), approximately 505m in length, that draw seawater from a depth of 60m and deliver it to the mix/de-aeration tank
  - Two HDPE outfall pipelines (outside diameter of 1,000mm), approximately 985m in length, that convey diluted tailings from the mix/de-aeration tank to approximately 200m depth in the Huon Gulf

Further information of the engineering of the DSTP system is provided below and detail is provided in the Tailings Management Engineering Design (Appendix Z).

6.10.2.2. Tailings Pump Station and Choke Station

Tailings from the Watut Process Plant will be thickened to recover water and process reagents and will be fed to a pump station at the process plant terrace.

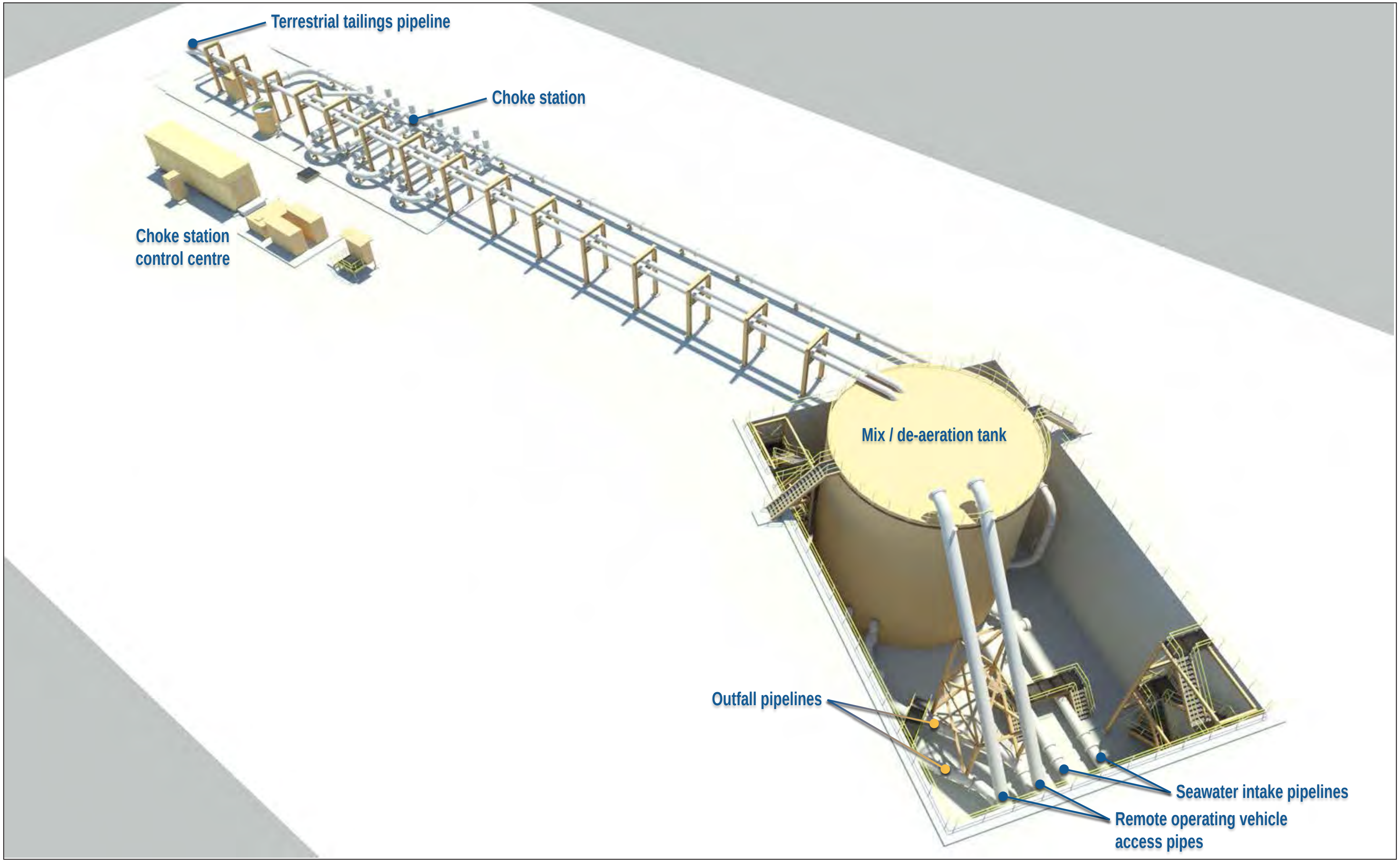
Tailings slurry from the terrestrial tailings pipeline will enter the Outfall System choke station located approximately 50m upstream of the mix/de-aeration tank (see Figure 6.19). The choke station will prevent low pressure flow and the resulting wear in the terrestrial tailings pipeline. A flow meter will also be provided at the choke station to monitor flow rate and provide input to the pipeline leak detection system. Two valves will be installed to shut down the pipeline and provide isolation for the choke station and mix/de-aeration tank. All valves and other choke station (and tank) equipment will have full emergency power.

6.10.2.3. Outfall System

The mix/de-aeration tank will receive tailings slurry from the terrestrial tailings pipeline (via the choke station), as well as seawater from the two seawater intake pipelines. Two seawater intake pipelines are required for the hydrodynamic balance of the tank. The mix/de-aeration tank will allow entrained air in the tailings slurry to escape to the atmosphere and will also dilute the tailings with seawater in a one-part tailings slurry to four-parts seawater ratio. This will happen at the same time and an internal baffle wall within the tank will help to generate turbulent mixing of the tailings with seawater, prevent short-circuiting within the tank and encourage the detrainment of air from the inflowing tailings. The resultant discharge from the mix/de-aeration tank is de-aerated and diluted tailings, via two outfall pipelines, at a depth of approximately 200m in the Huon Gulf.

Importantly, the rate of pre-discharge dilution has been selected so that the diluted tailings slurry will have a higher density than the receiving ocean water (see Appendix V, Site-wide Water and Mass Balance Modelling) so that a density current will form and flow down the sloping seafloor into deeper water, as shown conceptually in Figure 6.18.

The tailings slurry density and nearshore bathymetry mean that a gravity-driven system is feasible. The mix/de-aeration tank will be situated within a dry moat with its base at 8.25m below sea level, which allows for passive filling of the tank by inflowing seawater. The height of the inflowing slurry and seawater will fluctuate naturally within the mix/de-aeration tank. This system requires negligible power consumption to function during normal operating conditions.



coffey A TETRA TECH COMPANY	Date: 26.04.2018 Project: 754-ENAUABTF100520DD File Name: 0520DD_10_F06.19_GRA	WAFI-GOLPU JOINT VENTURE Wafi-Golpu Project	3D representation of the DSTP Outfall System and choke station	Figure No: 6.19

The purpose of the moat, with dimensions of approximately 30m by 20m (600m^2) and its base 8.25m below sea level, will be to provide:

- An overflow capture and storage volume
- An area for inspection and servicing of the tank, valves and flow meters

The mix/de-aeration tank and dry moat is proposed to be located approximately 6km east of the Port Facilities Area, 120m inshore of the beach and approximately 500m west of the Busu River. The setback distance of the mix/de-aeration tank from the shoreline is to provide protection against potential shoreline instability. The mix/de-aeration tank and moat are designed to withstand the 1 in 200-year flood levels at the nearshore outfall area, and the pipelines have been designed to withstand the 1 in 200-year storm wave conditions from the east and southeast.

Excluding scheduled and unscheduled shutdowns, the mix/de-aeration tank is intended to operate 365 days per year.

The seawater intake and outfall pipelines will be buried in the beach sands. Figure 6.20 shows typical trench sections for outfall and seawater intake pipelines. Ballast weights will be used to ensure stability during operations. If necessary, the submarine sections of the pipelines will also be rock-armoured.

Co-located with the mix/de-aeration tank will be:

- Laydown and storage area located to the north of the mix/de-aeration tank, which will store pipes after construction is complete
- Pipe and choke station
- Facility building and generators
- Diesel storage
- Parking and turnaround area

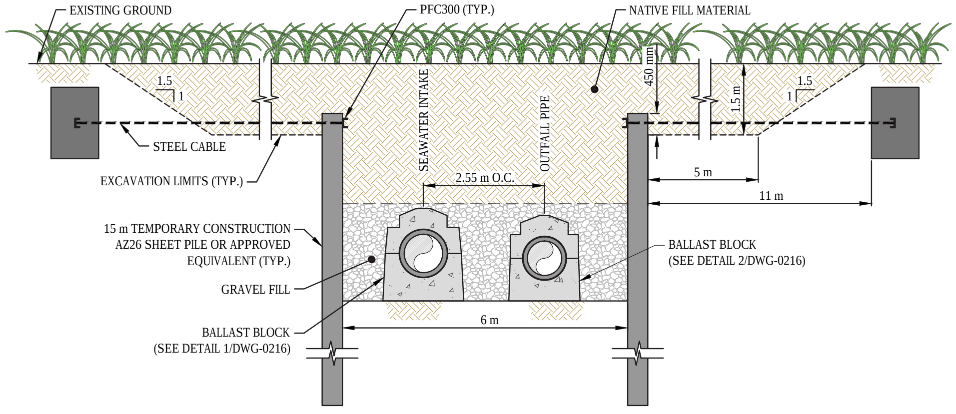
All facilities, with the exception of the access track, will be contained within a perimeter fence. The total area of disturbance associated with construction of the facility will be approximately 4.3ha. The total permanent facility size will be approximate 2.5ha.

6.10.2.4. Construction of the Outfall System

Construction of the Outfall System will take approximately 19 months from mobilisation and will be constructed as follows:

- The access track to the mix/de-aeration tank will first be built, the site cleared and laydown area established. The dry moat will then be established for construction of the mix/de-aeration tank.
- The mix/de-aeration tank, piping and other infrastructure will be constructed
- The HDPE pipes will be strung together (preferably on land), fitted with ballast blocks and blind flanges at both ends, and towed into their approximate alignment
- The terrestrial and nearshore section of the pipes will be buried in a trench overlain by protective rip-rap to minimise scouring of the pipe due to wave action
- The inshore ends will be attached to the mix/de-aeration tank
- During sinking, water will be pumped into the landward end of the floating pipes, causing that part of the pipe to sink; this construction method is termed 'S-bend sinking'
- The sinking process will be monitored by remote operating vehicle (ROV), and by monitoring the flow of water into the pipes versus the point of contact with the seabed

Once the seawater intake and outfall pipelines have been installed, the Outfall System will be commissioned.



A 0215 **TYPICAL TRENCH SECTION (STA. 0+025 - 0+115≈)**
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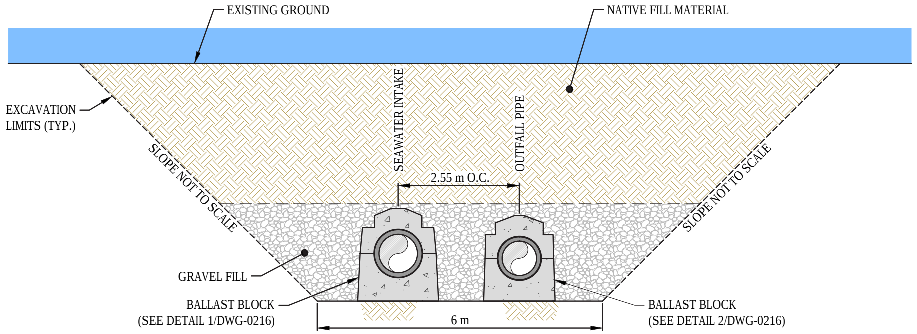

NOTE:

1. TEMPORARY SHEET PILES WITH INTERNAL BRACING OR OPEN TRENCH METHOD MAY BE USED FOR CONSTRUCTION OF THIS SECTION.

B 0215 **TYPICAL TRENCH SECTION (STA. 0+115 - 0+150≈)**
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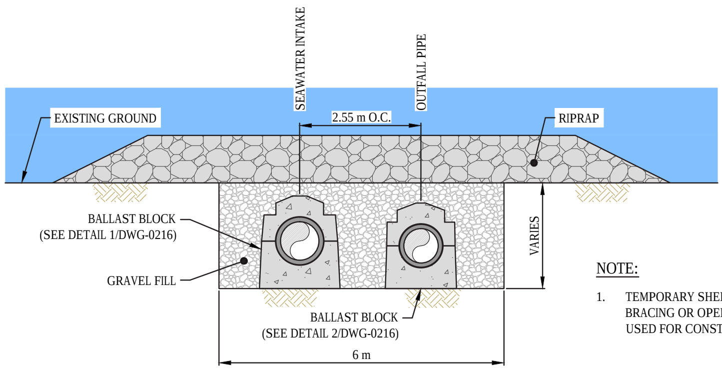

NOTE:

1. TEMPORARY SHEET PILES WITH INTERNAL BRACING OR OPEN TRENCH METHOD MAY BE USED FOR CONSTRUCTION OF THIS SECTION.

C 0215 **TYPICAL TRENCH SECTION (STA. 0+150 - 0+210≈)**
SCALE: 1:100

NOTES

1. All units are in millimeters unless noted otherwise.
2. Stationing shown on this drawing is approximate and is based on outfall pipe alignment.
3. Preliminary design based on assumed poor ground conditions. Existing ground conditions unknown.

Source:
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Example of typical trench sections for outfall and seawater intake pipelines

Figure No:
6.20

6.10.2.5. Operation of the Outfall System

Modelling by Tetra Tech using high-precision swath bathymetry has confirmed that there is predicted to be no deposition of tailings solids near the outfall terminus and so there is no risk of plugging the DSTP outfall (Appendix J, Density Current, Plume Dispersion and Hydrodynamic Modelling), confirming the suitability of the DSTP outfall location.

Once installed, the operation of the Outfall System will be monitored by control rooms at the Watut Process Plant. The mix/de-aeration tank will be equipped with a telemetry alarm system to alert the control rooms if the fluid level in the mix/de-aeration tank drops below a predetermined minimum elevation. Should this occur, the control rooms personnel will immediately shut down the overland pipeline pumping system.

An external and internal inspection of the mix/deaeration tank, seawater intake and the outfall pipeline will occur at least once per year. Access pipes are provided at the top of the mix/de-aeration tank, connected to each outfall pipeline (see Figure 6.19), which allows a pipeline ROV to be fed into each of the ocean outfall pipelines during scheduled maintenance and inspection. These ROVs will be used to inspect the outside of the outfall pipelines for wear, and smart pipeline inspection gauges with ultrasound will be used to inspect deposition of tailings material within the pipelines.

Consistent with the recommendation of SAMS (2010), spare seawater intake and tailings outfall pipelines will be stored adjacent to the mix/de-aeration tank throughout the life of the mine in the event there is a need to replace part or all of the Outfall System. Pumping systems may be considered should problems develop with the seawater intake pipeline.

6.11. Infrastructure Corridor

The Infrastructure Corridor will host three buried pipelines, roads and bridges. A concentrate pipeline, fuel pipeline and terrestrial tailings pipeline will span the entire length of the Infrastructure Corridor (shown in Figure 1.1) from the Mine Area to the Port Facilities Area. The Mine Access Road and Northern Access Road (discussed in Section 6.4) will connect the Mine Area and the Highlands Highway, near Zifasing. Bridges will be constructed across the Watut and Markham rivers.

The Mine Access Road will commence at the process plant terrace and follow the existing WGJV-operated Watut Valley Road to its intersection with the existing Link Road. The Northern Access Road will commence at the point of intersection and continue north to the point where it crosses the Watut River, then northeast across the Markham River, approximately 3.5km to the west of its confluence with the Watut River.

After crossing the Markham River, the Infrastructure Corridor will continue north just south of the Highlands Highway where it will intersect the PNG Power high-voltage transmission line corridor. Here the concentrate, fuel and terrestrial tailings pipelines will split from the Northern Access Road (which goes on to terminate at the Highlands Highway) and turn east following the PNG Power high-voltage transmission line corridor approximately 3.5km west of the settlement of Yalu along the Highlands Highway.

Near Yalu, the Infrastructure Corridor will deviate southeast from the PNG Power high-voltage transmission line corridor through partially-cleared forest and gardens along the upper terrace of the Markham River floodplain north of the Port of Lae.

The concentrate and fuel pipelines terminate at, or near, the Port Facilities Area at the Port of Lae; however, beyond the Port Facilities Area, the Infrastructure Corridor (hosting the terrestrial tailings pipeline) continues through Lae to the Outfall Area, located between the Wagang settlement and mouth of the Busu River.

The nominal width of the Infrastructure Corridor will vary along its length, with the narrowest section being through Lae to the Outfall Area. Here the corridor will be located under the existing road reserves and be limited to a single lane of the road. Detailed planning will be undertaken in order to maintain public safety and minimise disruption to abutting residences, businesses, schools, government services and traffic. The widest section of the Infrastructure Corridor will likely be between the Mine Area and Zifasing to accommodate the pipelines, Mine Access and Northern Access roads. The width of the corridor will be optimised as engineering progresses, however for the purpose of the impact assessment discussed in this EIS, a conservative width of the Infrastructure Corridor has been assumed. This consists of a 70m-wide corridor for parts of the Infrastructure Corridor on slopes less than 20 degrees, and a 100m-wide corridor for the remaining parts on 20 to 30 degree slopes (see Chapter 14, Physical and Biological Environment Impact Assessment, for further discussion). The actual extent of land disturbance and vegetation clearance is likely to be less than this and the extent of clearing will be minimised within the sections of the Infrastructure Corridor.

Land investigations have been undertaken to confirm land ownership and identify compensation requirements (e.g., damage, deprivation and economic or physical displacement) along the proposed Infrastructure Corridor. While the majority of the Infrastructure Corridor is expected to pass through customary land, it will also pass through several State leases on its approach to Port of Lae. Compensation will be agreed with landholders (as defined in the *Mining Act 1992*) prior to commencement of construction on the affected land.

Unexploded ordnance from battles between Allied and Japanese armed forces in and around Lae during World War II poses potential safety risks during construction. An unexploded ordnance survey will be conducted prior to site clearing and grading, with clearance of any ordnance uncovered managed by the PNG Army. The area of the Infrastructure Corridor between Zifasing and Lae has the highest probability of unexploded ordnance finds (refer to Chapter 13, Cultural Heritage Characterisation).

Prior to clearing, grading or trench excavation, temporary fencing may be established near sensitive areas to limit disturbance and minimise potential impacts to community safety. Clearing will include the removal of vegetation and large rocks to the side of the right of way. Trees and large shrub debris will be felled and stockpiled alongside the edge of the corridor. Where practicable, timber cleared will be used during construction and landowners will also be permitted to use the timber.

Smaller vegetation moved to the side of the Infrastructure Corridor will be managed to assist with erosion control and provide a ready seed source for natural revegetation.

Grading of the Infrastructure Corridor will involve progressive stripping of topsoil, where practicable, which may be reused as fill and stockpiled in spoil areas along the roadways. No sidecasting is planned.

6.11.1. Pipelines

The concentrate and terrestrial tailings pipelines will transport the concentrate and tailings slurries from the process plant terrace located within the Mine Area to the Coastal Area. The concentrate pipeline will terminate at the concentrate filtration plant in the Port Facilities Area at the Port of Lae, while the terrestrial tailings pipeline will continue through Lae to the Outfall Area, located between the Wagang village and the mouth of the Busu River (see Figure 6.1).

The fuel pipeline will transport fuel from the Lae Bulk Fuel Storage Facility at or near the Port of Lae to a storage facility at the power generation facility in the Mine Area. In the absence of suitable State of PNG guidelines, the fuel pipeline will be designed in accordance with Australian Standard 2885, which is the overarching standard that applies to the pipeline industry in Australia which relates to the design, construction, testing, operations and maintenance of petroleum (and gas) pipelines.

All pipelines will have cathodic protection for corrosion control, leak detection systems and pigging systems to enable cleaning and internal inspection of the pipelines.

The conceptual design parameters for the pipelines are provided in Table 6.8. Parameters are approximate and may be optimised as engineering progresses.

Table 6.8: Pipeline parameters

Pipeline	Nominal Pipeline Diameter	Pipeline Length (km)	Design Capacity	Design Flow Rate	Design Pressure	Material	Lined
Concentrate	200mm	103	130 tph (dry)	134m³/hr	27.0 MPa	Steel	6mm HDPE
Fuel	200mm	86.5	15.5kL/h	0.0043m³/s	200bar	Steel	No
Terrestrial tailings	700mm	103	1,934 tph (dry)	2,273m³/hr	8,750kPa	Steel	17.4mm HDPE

6.11.1.1. Construction

All pipelines within the Infrastructure Corridor will be buried to minimise ongoing land disturbance and to protect the pipelines from surface interference, except at valve or pump stations. With the exception of the fuel pipeline (which will conform to relevant standards), the depth of burial will conform to industry practices with consideration of land use. Where feasible, the onshore pipelines will be constructed in existing disturbed areas such as in, or adjacent to roads, existing access tracks and within the PNG Power high-voltage transmission line corridor.

Figure 6.21 illustrates a typical onshore pipeline construction sequence.

The rate of pipeline trenching will largely depend on the nature of the material and terrain traversed. Indicative advancement rates are provided in Table 6.9.

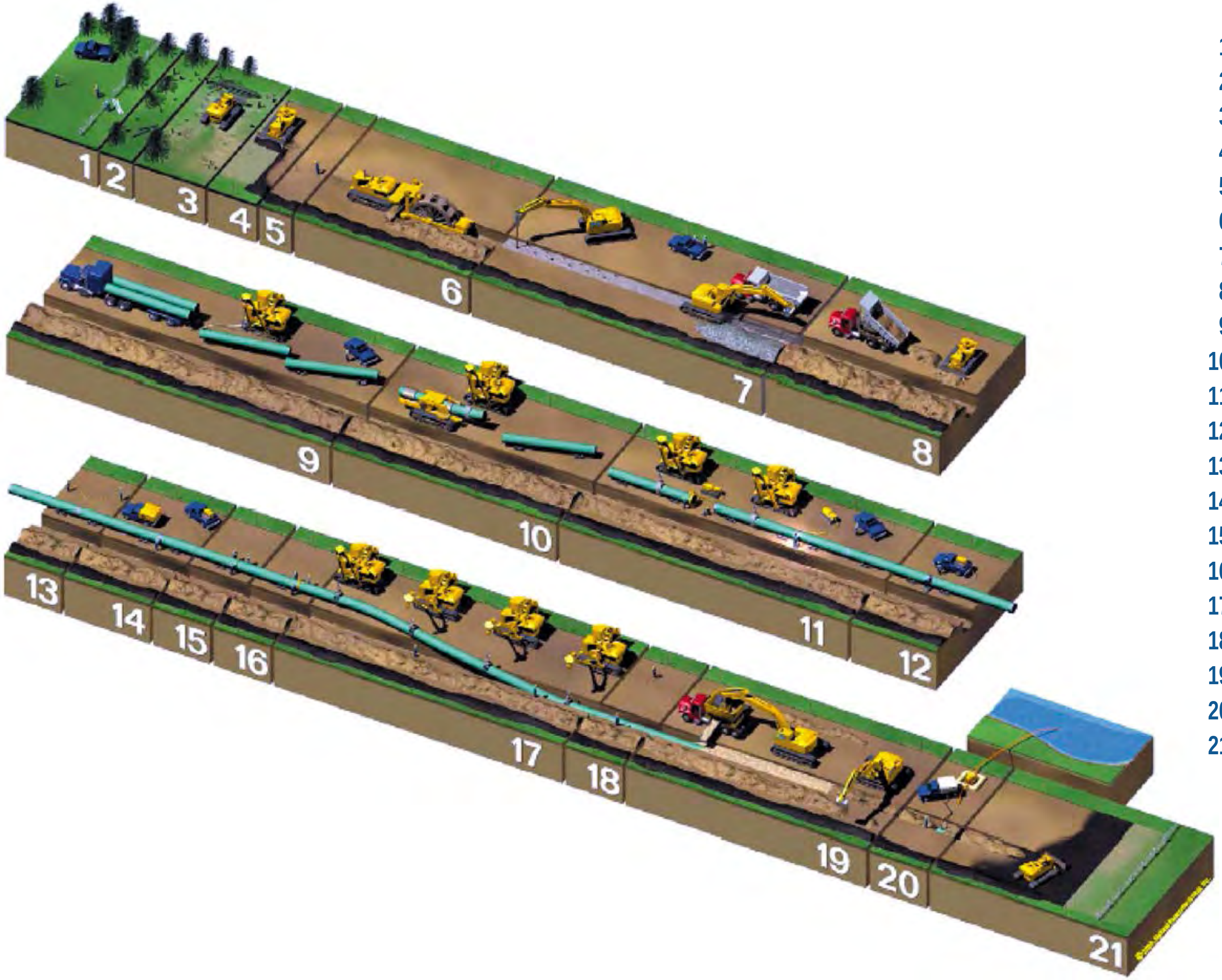
Table 6.9: Indicative pipeline trench rates

Topography	Approximate Trench Progress
Mostly flat, low water table areas	300m/day
Undulating, high water table areas	150m/day
Steep slope areas	50m/day
Flat, working within roads	50m/day

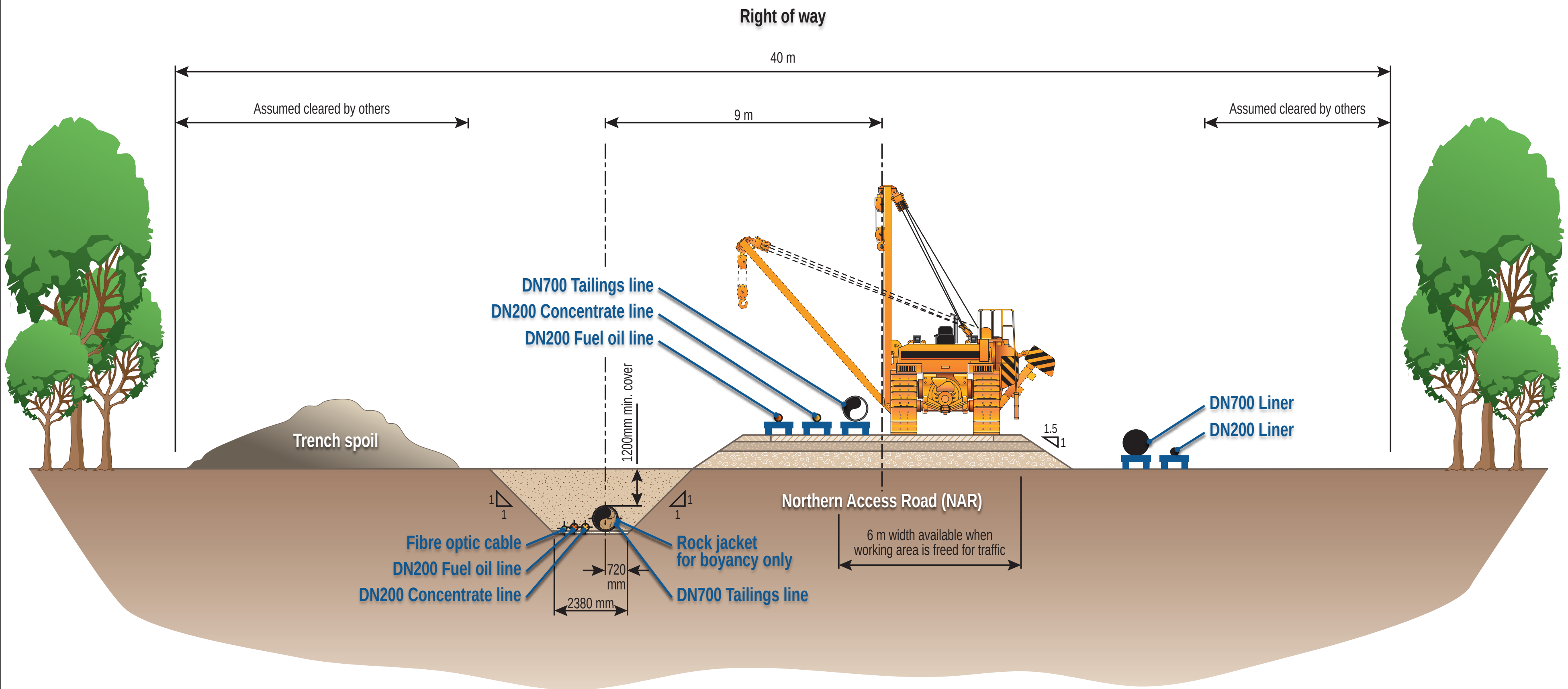
A typical pipeline corridor cross-section is provided in Figure 6.22.

Minor unsealed road crossings and creeks will be trenched, and main road crossings will be thrust bored. In urban Lae, the buried pipelines will be provided with additional protection from damage such as pipe-in-pipe construction or concrete capping.

The pipelines will cross numerous watercourses along the length of the Infrastructure Corridor. The methods used to traverse watercourses will be determined on a case-by-case basis and will largely depend on the width, depth and flow rate of a watercourse as well as the stability of its banks.



1 Survey and pegging
2 Clearing
3 Grading
4 Soil stripping
5 Pegging centreline of trench
6 Trenching (wheel ditcher)
7 Trenching (rock)
8 Padding trench bottom
9 Transport and stringing pipe
10 Bending pipe
11 Line-up initial weld
12 Final weld
13 As-built footage
14 X-ray inspection weld repair
15 Pipeline coating
16 Pipeline inspection
17 Lowering pipe into trench
18 As-built survey
19 Padding, backfill, grading
20 Hydrostatic testing
21 Rehabilitation and clean-up



coffey A TETRA TECH COMPANY	Date: 26.04.2018 Project: 754-ENAUABTF100520DD File Name: 0520DD_10_F06.22_GRA	WAFI-GOLPU JOINT VENTURE Wafi-Golpu Project	Typical pipeline right-of-way cross-section	Figure No: 6.22

Trenching and direct pipe trenchless method are the proposed pipeline watercourse crossing methods. Trenching will be used as a first preference for watercourse crossings where the water is allowed to continually flow over the construction crossing. Figure 6.23 shows the layout of a typical pipeline watercourse crossing construction site.

For large, deep or fast flowing watercourses, the direct pipe method will be used to cross the watercourses. The direct pipe method is similar to microtunnelling, but the entire steel casing pipeline is fabricated and welded behind the tunnel-boring machine. The assembly is pushed forward by a pipe thruster as the tunnel-boring machine simultaneously excavates the earth along the planned alignment where it exits at the predetermined exit point.

Watercourse crossings will require additional workspace for the handling and storage of excavated materials coming from the watercourse and its banks or the drilling rig used at horizontally directionally drilled crossing. The amount of clearing at watercourse crossings will depend on the watercourse size and the crossing method.

Watercourse beds and banks will be rehabilitated to their preconstruction profile to the extent practicable.

Cathodic protection will be installed to prevent corrosion of the pipelines. Marker tape will be placed on top of the shallowest pipeline within the trench to provide warning for potential future excavations over the pipeline.

6.11.1.1.1. Right of Way Reinstatement

Prior to backfilling of the trench, as-built surveys will be undertaken to record coordinates and depths of the buried pipelines. The trench will be backfilled and the ground compacted and crowned to allow for settlement over the trench. The disturbed area will be graded, contoured and where possible, topsoil replaced to promote natural revegetation.

Ground signage will be installed along the pipeline route to assist with pipeline location and safety.

6.11.1.1.2. Pressure Testing

Pipeline integrity will be tested by pressure testing using hydrostatic/hydrotesting. Hydrotesting will be performed using water as the test medium and will involve filling the pipeline with water to pressurise the pipeline above maximum operation pressure. The test pressure will be held for a predetermined period of to verify the integrity of the pipe and welded joints. Any failed pipe and joints will be excavated and replaced. Pressure testing is repeated after repairs are completed.

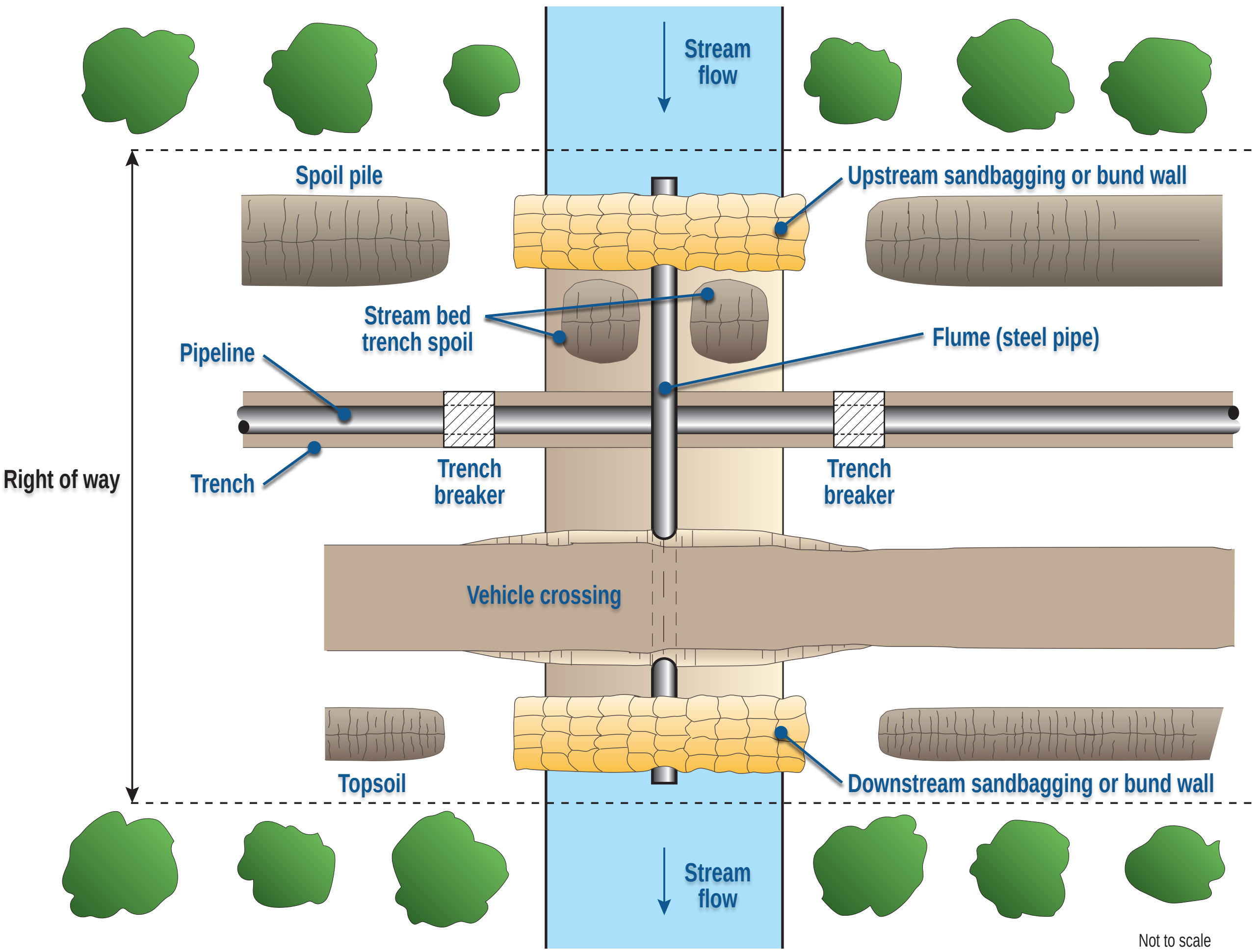
Water for the hydrostatic testing will be sourced from local watercourses and treated if required prior to discharge. Detailed information on the management of this process will be developed during the detailed design phase.

6.11.2. Roads and Bridges

Roads and permanent bridges within the Infrastructure Corridor will be constructed or upgraded sequentially to avoid delaying the construction of other Project components. Newly constructed and upgraded roads will include the Mine Access Road, Northern Access Road and pipeline access tracks.

Construction of the roads and pipeline access tracks will generally include:

- Installing culverts or temporary construction bridges
- Delivery of rock from Project quarries
- Dumping and spreading rock material over the roadway surfaces
- Abutment or gabion construction, if required



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Wafi-Golpu Project

Typical pipeline watercourse crossing (open trench, flume pipe method)

Figure No: 6.23

The Mine Access and Northern Access roads will be nominally 10m wide. The roads will be unsealed and designed to a 1 in 20-year annual exceedance probability flood event and consider the PNG Department of Works Road Design Manual.

Access tracks suitable for use by 4WD vehicles will provide access for the pipelines, valve stations and cathodic injection stations.

Permanent bridges will be constructed at the Bavaga, Watut, Markham and Leron rivers. Construction of the bridges will likely include:

- Installing bridge abutments, gabions and footings
- Placing bridge spans on the abutments and footings using cranes and incremental launching and securing the spans in place.

Bridges will be designed to a 1 in 100-year annual exceedance probability flood event. The approximate dimensions of these bridges are listed in Table 6.10.

Table 6.10: Summary of Northern Access Road bridges

Bridge Location	Approximate Total Span Length (m)	Roadway Width (m)	Pedestrian Walkway Width (m)
Bavaga River	20	4.2	1.2
Watut River	200	4.2	1.2
Markham River	450	4.2	1.2
Leron River 1	40	4.2	1.2
Leron River 2	20	4.2	0

In addition to roads and bridges, laydown and turning areas may be required, particularly along the Infrastructure Corridor. Where possible, these will be located within the construction corridor or within existing disturbed areas. The size of these areas will be determined on a case-by-case basis.

The Watut Services Road, if constructed, will be located in a flat, swampy area, which can be inundated during the wet period. This road has two main watercourse crossings and these crossings will likely include culverts and the road will be mostly fill material to cater for the type of environment. The Resettlement Road, if constructed, will traverse at least five steep gradients and will cross six rivers by bridges. These roads will be constructed as all-weather roads with widths of 6.5 to 7m wide and according to the PNG Department of Works Road Design Manual.

6.12. Port Area

Within the Port of Lae, Project facilities and activities in the Port Area will include concentrate filtration, handling, storage and ship loading at the Port Facilities Area (see Section 6.13), and storage of IFO at the Lae bulk fuel storage facility (see Section 6.15).

Receipt of sea freight during the construction phase of the Project is expected to be accommodated within the current Port of Lae facilities. Should the need arise where larger vessels than those typically operating at the port occur, it is expected that only two to three vessels of this larger size would be needed over the entire construction period. During the operations phase, concentrate export and bulk fuel import requirements will require vessel movements at the port and are discussed in more detail in sections 6.13.6 and 6.15.2, respectively. A proposed location for the Port Facilities Area has been identified near Berth 6 (Figure 6.1)

6.13. Port Facilities Area

The proposed port facilities include the concentrate filtration plant and materials handling, storage and ship loading facilities. The main function of the concentrate filtration plant is to separate the concentrate from the carrier water and to dry it prior to export. The facilities will occupy approximately 3ha and include covered conveyors for ship loading, a wastewater treatment plant and an enclosed concentrate storage shed. An indicative layout is provided in Figure 6.24.

6.13.1. Concentrate Filtration Plant

The concentrate filtration plant will operate 24 hours per day, 365 days per year apart from scheduled and unscheduled maintenance shutdowns. Concentrate slurry transported via pipeline from the Watut Process Plant will be initially stored in one of three storage tanks before being dewatered using a pressure filter. Filtered concentrate (around 10% moisture) will be gravity fed into the storage shed and stored under cover.

From the concentrate storage shed, concentrate will be loaded for export via covered conveyors equipped with rain covers and drip / spillage trays. The conveyor loading area will also be within an enclosed building to contain dust, noise and light to allow 24-hour operation, but will be naturally ventilated to avoid build-up of exhaust fumes from mobile equipment. Once ship loading is complete, the mobile conveyors will be moved to the wash bay and cleaned prior to storage outside the concentrate storage shed. Export of the concentrate overseas will be by ship, with an estimated 18 shipments per year (i.e., about one shipment every three weeks).

The concentrate storage tanks are designed to hold the equivalent of 24 hours' concentrate to cater for maintenance and unplanned outages.

Emergency containment of the entire concentrate pipeline contents is provided by the surplus tank capacity, the containment pond and bunded area at the Port Facilities Area.

A dangerous goods assessment by ToxConsult (2017) determined that the concentrate does not meet the conditions considered to be 'harmful to the marine environment' under the revised Prevention of Pollution from Ships (MARPOL) Annex V criteria.

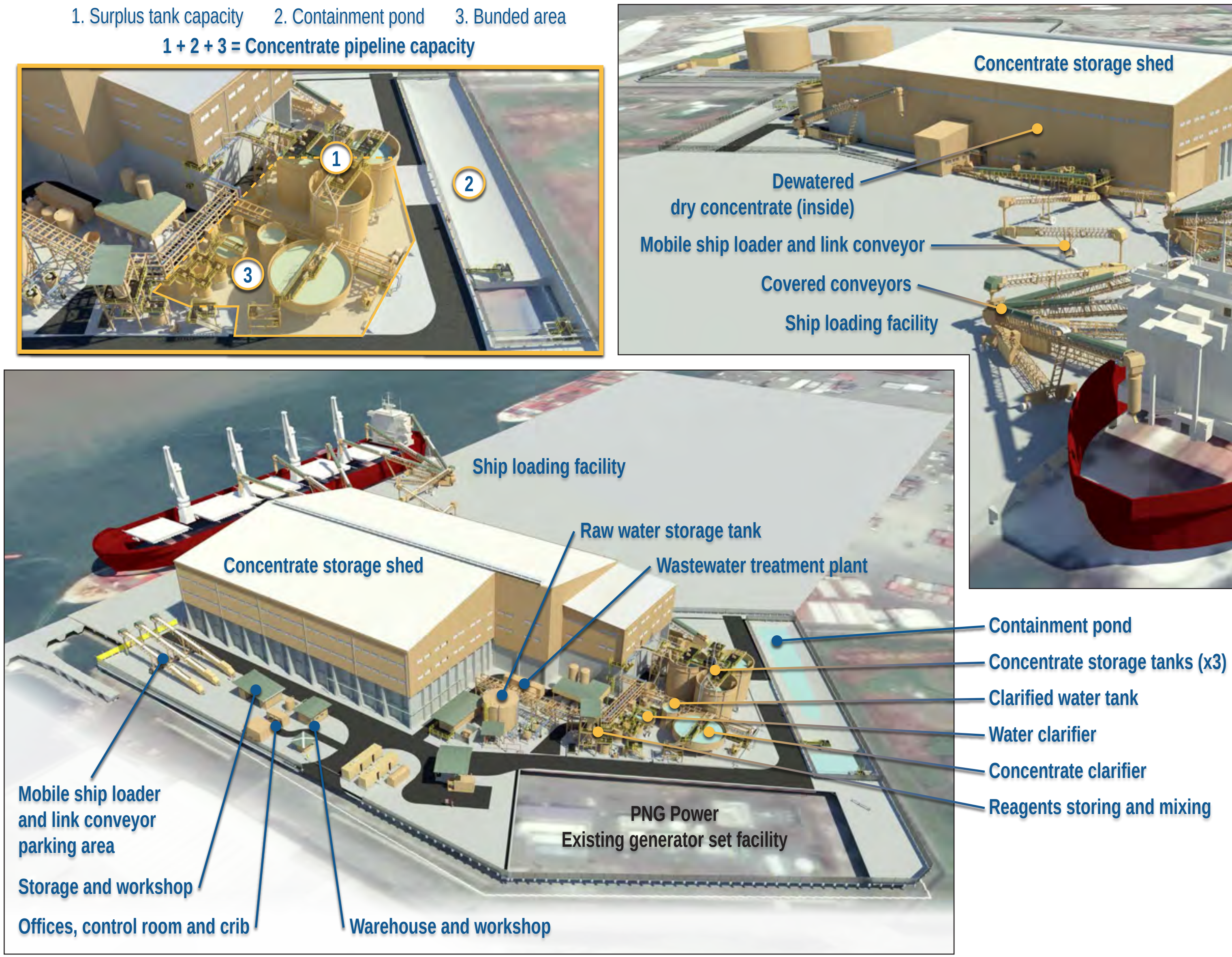
6.13.2. Wastewater Treatment Plant and Filtrate Discharge

A wastewater treatment plant will treat filtrate from the concentrate slurry and stormwater captured on site. The plant will consist of pH adjustment and solids removal.

The filtrate will be continuously discharged to the marine environment in the vicinity of Berth 6, at a rate of around 30 litres per second during operations. The filtrate will be treated where necessary to comply with the PNG Environment (Water Quality Criteria) Regulation 2002 (PNG ER) criteria for the marine environment.

6.13.3. Potable Water

The potable water consumption requirements for concentrate filtration will be low and trucked to site. The system will supply water to relevant areas of the Port Facilities Area (e.g., site buildings, safety showers and emergency eyewash stations).



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WAFI-GOLPU JOINT VENTURE

Wafi-Golpu Project

Port Facilities Area

Figure No: 6.24

INDD Reference: 0520DD_10_GRA011.indd 5

6.13.4. Containment Pond

Under normal operating conditions, rain water from the containment pond will be pumped to the clarifier to recover solids and treat the water to remove soluble contaminants (see Figure 6.24). Under storm conditions, the containment pond will collect site run-off. Bunds around reagent tanks will be sized for a 1 in 200 year storm events and are therefore unlikely to overflow. Reagent spills will be assessed and handled in accordance with the relevant material safety data sheets or processed through the water treatment plant.

The containment pond capacity (1,400m^3) is sufficient to hold the contents of an entire concentrate tank (800m^3) in the unlikely event of leakage or tank rupture.

There may be occasions, in particular after intense rainfall events, when the containment pond is filled with solution that is of suitable quality to be directly discharged to the ocean. In these circumstances, water in the containment pond will be tested and, if it meets permitted discharge criteria, will then be pumped directly to the treated water tank prior to discharge.

6.13.5. Concentrate Storage Shed

The enclosed concentrate storage shed will protect the concentrate from the weather and limit fugitive concentrate dust emissions. The concentrate storage facility roof drainage and clean water run-off will be directed to the existing Port of Lae sub-terrain drainage system for direct ocean discharge. The shed will be designed with natural ventilation, allowing for future forced air ventilation and dust extraction if negative pressure is required to limit fugitive concentrate dust emissions.

6.13.6. Ship Loading

Cargoes of up to 40,000t of concentrate will be loaded onto each ship. Ship loading will be conducted with duplicate ship loading equipment at a combined rate of approximately 1,200 wet tonnes per hour.

6.13.7. Diesel Fuel Storage and Distribution

Two diesel fuel storage areas are proposed; one for refuelling of equipment and another supplying diesel driven generators that supply emergency power to the concentrate filtration plant. Both the refuelling storage vessel and the emergency generator fuel storage tank will be self-bunded, double-skinned storage tanks.

6.13.8. Power Supply

Electrical power will be sourced from an independent power provider such as PNG Power Limited or some other third-party provider. A container-mounted electrical substation will be installed at the Port Facilities Area. Diesel generators will be onsite for back up.

6.13.9. Ancillary Buildings

The Port Facilities will include the following containerised buildings:

- Office, which also houses the control room
- Crib room
- Ablutions, change room and laboratory for preparation of concentrate samples for analysis
- Reagent storage warehouse
- Motor control centre

Waste streams from each of these buildings will be directed to a stand-alone sewage treatment plant from where solid waste will be recovered by vacuum truck for off-site disposal by a local hazardous waste contractor while liquids will be pumped to the Port's sewage facility.

6.13.10. Site Establishment

Construction of the facilities is estimated to take 18 months. The Port Facilities will be sited within a fenced compound within the Port of Lae precinct. Access to the facilities will be via existing roads to the security-control point.

6.14. Ancillary Project Infrastructure

6.14.1. Laydown Areas

Each major construction centre will have its own dedicated laydown area for the temporary storage of materials to be used during the initial construction and ongoing maintenance of Project-related facilities. This will include the existing Bavaga laydown yard and Finchif 2 construction camp as well as new laydown areas at:

- Watut Process Plant
- Portal terraces
- Power generation facilities
- Watut River crossing
- Markham River crossing
- Outfall Area
- Port of Lae

Laydown areas will also be required along the Infrastructure Corridor, with specific locations identified prior to execution in consultation with landowners and the contractors engaged to construct the infrastructure.

6.14.2. Power Generation and Distribution

Due to the remote location of the Mine Area, provision of fuel and electricity will be one of the largest operating costs for the Project.

Power generation using imported fuel oil was assessed to be the most economic and reliable way to meet mine power demand over the life of the Project.

The power generation and distribution for the Project is described below.

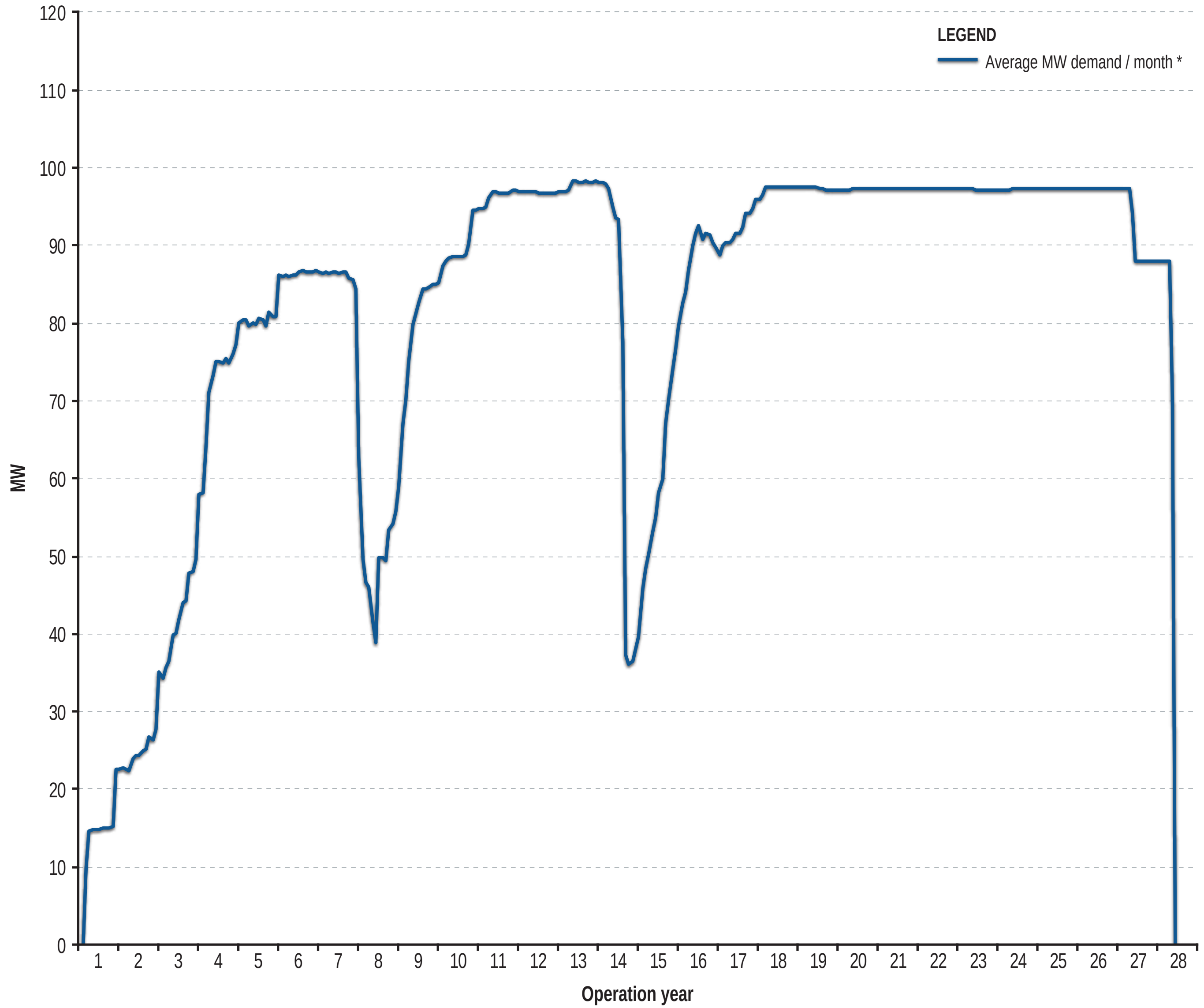
6.14.2.1. Construction

During the construction phase of the Project, power will be provided by on-site diesel generators. Approximately 20 generators (depending on the units selected) are expected to be used for surface and underground works.

6.14.2.2. Operations

For the operations phase, the WGJV proposes to construct and operate a power generation facility using reciprocating engines to supply power for the mine, process plant and accommodation facilities as described below.

The estimated maximum demand profile for the Project is illustrated in Figure 6.25. The large step changes in demand are largely defined by the start of ore treatment and movement of ore from each additional block cave production levels to the surface.



Note:
* Maximum Demand Profile may vary from this profile

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WAFI-GOLPU JOINT VENTURE

Wafi-Golpu Project

Estimated average power demand profile

Figure No: 6.25

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The change in power demand profile of the Project necessitated a two-phase development approach for the bulk power supply: Phase 1 to meet the initial power demand and Phase 2 to meet the peak power demand with the mine throughput at or close to full production.

6.14.2.3. Infrastructure Requirements

Three separate points of supply are necessary for Project-wide permanent power requirements. These are:

- Mine Area. The largest point of supply will be the power generation facilities, with 132kV distributed to the Mine Area electrical switchyard located on the process plant terrace (Figure 6.6). To ensure reliability of supply, two 132kV circuits, one overhead and one buried, will be used. The annual power supply reliability target at the maximum demand level is 99.9%.
- Port Facilities Area. The second point of supply is for the concentrate filtration plant. Electrical power will be sourced from an independent power provider such as PNG Power Limited or some other third-party provider.
- Outfall Area. The third point of supply will be from generator facilities. The loads required for the Outfall System operation are small and the implementation of small-scale alternative supplies is appropriate for such requirements.

The power generation facilities (for the Mine Area only) are proposed to be located approximately 6.5km north of the Watut Process Plant on an existing cleared pad (Finchif 2) (see Figure 1.2). The site has already been partially developed and graded but will require some earthworks to make it suitable for the heavy foundations to accommodate the generator sets. The power generation facilities are proposed to be constructed in two stages. The first stage consists of nine 10MW generator sets to meet the initial power demand of 56MW. The second stage will accommodate the Project's peak power demand of approximately 100MW through the addition of five 10MW units taking the total to 14 generator sets. The first stage of the power generation facilities construction will include all civil and infrastructure works to construct the power generation facilities and will achieve operation one to three months prior to the Watut Process Plant start-up.

Several power generation technologies have been evaluated to provide a reliable power supply for the Project, with further details provided in Chapter 7, Assessment of Alternatives. The use of multiple medium speed mid-range reciprocating compression ignition engines of ~10MW size was selected as the most feasible option. The ultimate configuration will comprise 12 operating generators and 2 standby generators.

The power generation facilities is expected to be operated using intermediate fuel oil (IFO). Section 6.15.1 provides details regarding IFO importation, handling, distribution and storage.

6.14.3. Accommodation Facilities

The existing Wafi and Finchif Construction Accommodation facilities (see Figure 1.2) will be operational during the construction phase only. The Wafi Accommodation Facility has a current capacity of 250 persons and the Finchif Construction Accommodation Facility will be expanded to accommodate up to 1,000 people. The facilities will upgrade existing services to source water, generate power and manage sewage.

The Fere Accommodation Facility will be used for both the construction and operations phases and have capacity to house 1,400 people. Facilities will include accommodation units, ablution facilities, kitchen and mess facilities, recreation facilities, laundry facilities and a medical centre. Sewage will be treated by a sewage treatment plant located at the camp.

Each facility will be equipped with onsite generators for initial and emergency power, and will be connected to the Mine Area grid once bulk power is available.

During construction of the Infrastructure Corridor between the village of Zifasing and Coastal Area, Outfall System and Port Facilities Area, Project personnel and contractors will be accommodated at existing accommodation facilities, at 11 Mile, outside Lae.

6.14.4. Borrow Pits, Quarry and River Gravel Extraction

Hard rock will be required for various Project activities and structures, e.g., concrete aggregates, retaining walls and road construction. Gravel will be required for use in the concrete batch plants, the preparation of gabion baskets and for the gravel wearing course on roads. This rock is expected to be sourced from borrow pits and gravel extraction sites from rivers in the vicinity of the Project Area.

Initially, hard rock is proposed to be extracted from the Northern Access Road, Migiki and Humphries sites (see Figure 1.2), and river gravel from Waime River, at a location east of Gingen village and on the northern side of the Demakwa Access Road (see Figure 1.1). Aggregate required to establish the Nambonga Decline will be sourced from Lower Papas and trucked to a nearby crushing and screening plant for processing and stockpiling (see Figure 1.2). Clay required to encapsulate PAF material in the Miapilli Waste Rock Dump may be sourced from the Miapilli Clay Borrow Pit, located in proximity to the waste rock dump (see Figure 6.5), but may also come from other borrow pits and quarries. These proposed borrow pits will be located as close as possible to the construction sites and are shown in Figure 1.2. Raw materials will be hauled along the upgraded Portal Haul Road to a concrete batching plant near the Nambonga Decline. Cement will be trucked to site in containerized loads via the existing Demakwa Access Road.

Additional sites that may be developed during the Project include a quarry at Mt Beamena and river gravel extraction from the Bavaga River (see Figure 1.2). If a quarry at Mt Beamena is required, it will require drilling and blasting once weathered overburden has been removed. Track-mounted rigs will be used for the blasthole drilling and haulage trucks will transport the rock.

Rock extracted from the Migiki Borrow Pit and the quarry at Mt Beamena will most likely require crushing and screening.

The quarry at Mt Beamena will include exposed faces with 6m to 8m bench heights and 4m to 6m bench widths, and an area for the storage of stripped topsoil, mulch and excavated rock. An access road will be developed from the Mine Access Road to the quarry.

Gravel extraction from the Waime River will be undertaken by an excavator operating from a levy adjacent to the river. The material will be washed, crushed and screened (via a small screen plant) in an area adjacent to the extraction site.

For Infrastructure Corridor work, similar borrow pits are likely to be established adjacent to the Busu, Erap and Markham rivers. Specific locations are yet to be determined. Gravel and aggregate may also be procured in Lae from established suppliers and trucked to the point of use.

6.14.5. Explosives Magazine

Other than quarrying, explosives will mainly be used during the excavation of the underground workings including declines, ventilation shafts, development drives and in the early years of the development of each block cave and associated drawbells. Some ongoing use of explosives is likely.

An explosives magazine will be located approximately 1km north of the Watut Process Plant with access via the Mine Access Road. The magazine itself will be an approximate

34m by 30m cleared and flattened area. A second explosives magazine will be located in proximity to the Nambonga Decline portal terrace. Explosive materials will be stored in secured containers on a pad with security fencing around it to prevent unauthorised entry. The magazines will have a 500m-radius safety zone.

An explosives supplier will deliver raw materials and explosives to the site, and will be responsible for the operation and management of site storage, emulsion facilities, magazine, delivery of explosives to charging sites, loading of long holes and the operation of a mobile pumping unit.

6.14.6. Concrete Batch Plants

Concrete batch plants established during construction will be used sporadically during the operations phase of the Project. The batching plants will be fully automated and consist of systems for weighing and control of cement, aggregate and batching. Concrete batch plants will be located at the crushing, screening and stockpile area adjacent the Lower Papas Aggregate Source and in the vicinity of the Nambonga Decline (during decline development only).

6.15. Fuel and Logistics

Bulk fuel will be delivered to the Mine Area via truck (diesel) and a fuel pipeline (IFO). Vehicular delivery will provide fuels to meet the needs of vehicles, diesel generators during construction and mobile equipment. The IFO will be transported from the Port of Lae via the fuel pipeline established within the Infrastructure Corridor, to support the on-site power generation facilities. The transport, storage and logistical arrangements for each provision is described below.

6.15.1. Bulk Fuel

Bulk fuels (diesel and oils) will be delivered to the Mine Area by fuel tankers and stored in above-ground tanks. Diesel will also be reticulated to a dedicated vehicle re-fuelling bay near the workshop to service the surface mobile equipment fleet. An expected 25 tanker deliveries per week will be required during the construction phase when fuel demand is greatest, associated with diesel generator consumption.

The tank farm will be designed to store the following fuels and lubricants:

- Diesel fuel
- Diesel engine oil
- Hydraulic oil
- Transmission oil
- Coolant
- Waste oil

Diesel will be stored in a series of 60,000L, self-bunded storage tanks. The tanks and bunding will be compliant with Australian Standard (AS) 1940-2017: the Storage and Handling of Flammable and Combustible Liquids.

Drums of aviation fuel will also be kept on site to support helicopter operations.

Bunds will be established around storage tanks and concrete pads will provide containment for drainage and spillage at delivery and unloading points for tankers and other supply trucks.

Fuel storage areas will be managed to ensure they comply with the intent of the relevant requirements of the Department of Environment and Conservation (DEC) Environmental

Code of Practice (ECoP) for Vehicle/Machinery Workshops and Petroleum (Hydrocarbons) Storage/Resale/Usage Sites (DEC, 1997) which has now been adopted by Conservation and Environment Protection Authority (CEPA).

6.15.2. Intermediate Fuel Oil Importation

Intermediate fuel oil (IFO) is expected to be the preferred fuel type to feed the power generation facilities in the Mine Area. The vessel requirements to import the volume needed for the Project is in the order of one tanker per month. The IFO ship unloading system will likely consist of a flexible coupling connection from the ship to the port fuel delivery pipeline.

6.15.3. Bulk Intermediate Fuel Oil Storage Facility at Lae

The bulk fuel storage facility is expected to be located within Port of Lae. The port fuel delivery pipeline will transfer IFO to the bulk fuel storage tanks by an underground pipeline. The bulk fuel storage facility is expected to consist of:

- Bulk fuel storage tanks
- Office/control room
- Workshop/store
- Pump station to transfer fuel to the Mine Area via pipeline
- Pig receiving and launcher station
- Oily water treatment
- Stormwater detention basin

6.15.4. Mine Area Bulk Fuel Storage Facility

The Mine Area bulk fuel storage facility, with provision for a minimum of 14 days' fuel (IFO) storage, will be located at the Finchif 2 site adjacent to the power generation facilities. Table 6.11 highlights the key features of the storage facility. This allows for continuous power generation throughout fuel delivery interruption and occasional pipeline maintenance.

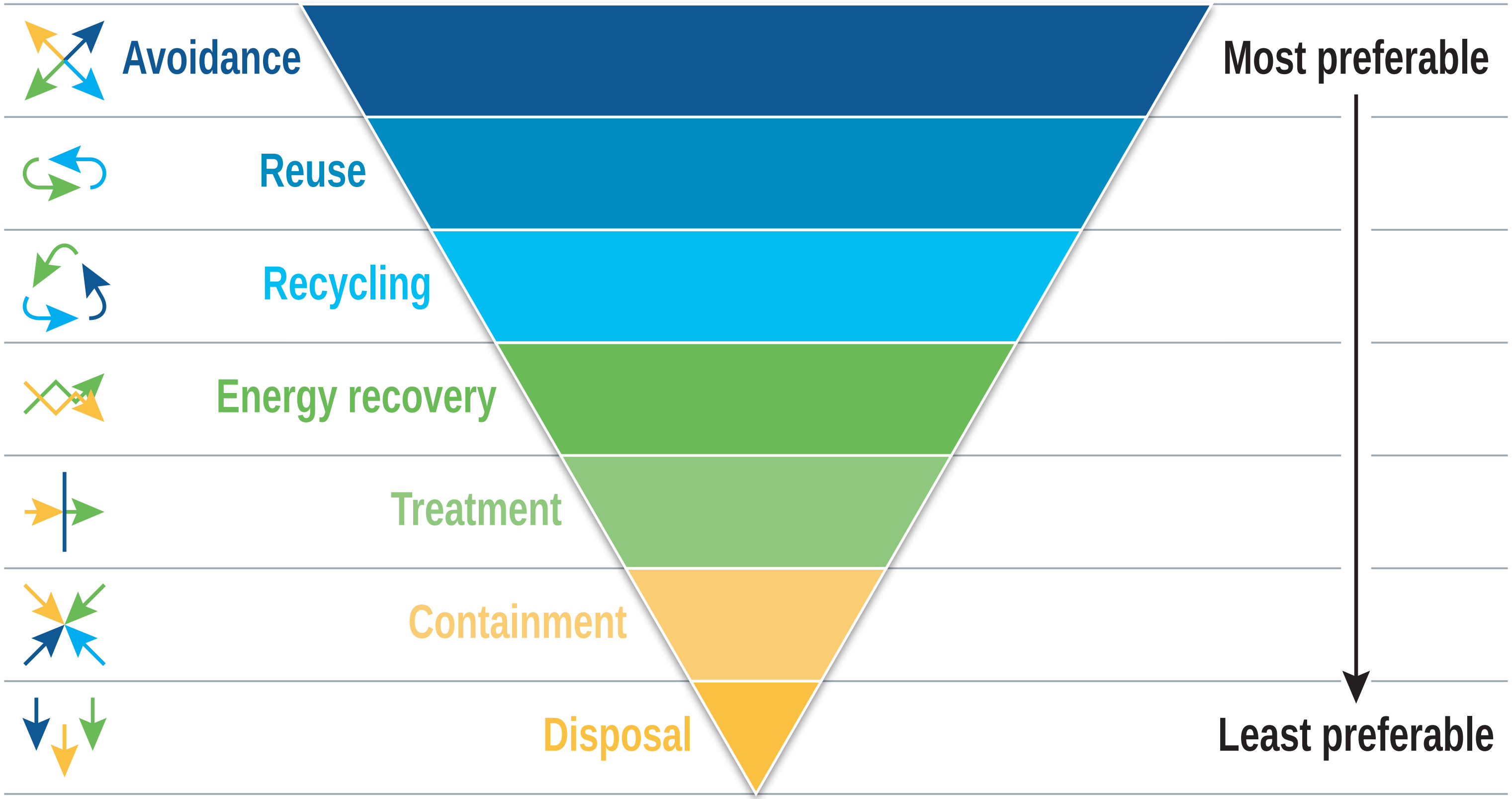
Table 6.11: Mine Area bulk fuel storage facility features

Parameter	Value
Bulk fuel storage	13,050kL
Number of tanks	2
Volume per tank	6,525kL
Indicative tank diameter	28m

6.16. Non-Mineral Waste Management

Wafi-Golpu Joint Venture intends to manage its wastes in accordance with the waste hierarchy shown in Figure 6.26 and will implement strategies to avoid or minimise the production of waste. Where generation of waste cannot be avoided, options to reuse or recycle wastes will be implemented where possible and disposal will be used as the last resort.

Hazardous and non-hazardous materials will be managed according to the Project Environmental Management Plan (Attachment 3).



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WAFI-GOLPU JOINT VENTURE

Wafi-Golpu Project

Waste management hierarchy

Figure No: 6.26

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Waste management strategies to be employed for non-mineral wastes include:

- Sale – Where an economic value can be obtained for waste materials, they will be sold to third parties who can either directly reuse or derive economic value from the waste resource, e.g., metals for recycling.
- Reuse – Where possible, packaging materials will be returned to suppliers for reuse, e.g., metal drums and batteries.
- Recycling – Where used materials can be reprocessed into useful materials or products by WGJV or third parties.
- Energy recovery – Where a waste material has calorific value that can be utilised, e.g., waste hydrocarbon that can be used as a supplementary fuel.
- Incineration (using a purpose built industrial incinerator) – To reduce the mass of wastes for disposal and reduce the hazard associated with chemical wastes.
- Landfill – In-ground disposal of waste which cannot be dealt with using any of the above strategies.

6.16.1. Mine Area

The non-mineral wastes that will be generated from the Mine Area during both the construction and operations phases of the Project have been identified and estimates made of amounts that will be generated. The broad categories of waste generated within the Mine Area are described in Table 6.12.

Table 6.12: Categories of non-mineral waste

Waste	Description
General Waste	Non-hazardous wastes from the consumption of goods during day-to-day activities. Including, but not limited to, office waste, consumables, tyres, conveyor belts, concrete and excluding putrescible wastes and recyclables.
Recyclable Waste	Materials that can be processed and used again. Including, but not limited to, paper, cardboard, plastics and metals, excluding timber waste.
Putrescible Waste	Waste containing organic matter capable of being decomposed by microorganisms and of such a character and proportion as to cause objectionable odours and attract birds or animals. Includes cooking oils and greases and other biodegradable organic matter from Fere Accommodation Facility.
Hazardous Waste	Hazardous waste includes any unwanted or discarded material (excluding radioactive material), which because of its physical, chemical or infectious characteristics can cause significant hazard to human health or the environment when improperly treated, stored, transported, disposed of or otherwise managed. Including but not limited to medical waste, chemicals, paint, batteries, lights, contaminated soils.
Timber/ Vegetation Waste	Construction timber and cleared vegetation.
Hydrocarbon Waste	Waste hydrocarbons and hydrocarbon-containing wastes including oily rags, greases, oil-water emulsions, drums and cans contaminated with hydrocarbons, and used oil filters.

Estimates of the quantities of these wastes are based on the anticipated utilisation of equipment, personnel numbers and mine and plant throughput. Estimated approximate waste quantities and the anticipated disposal pathway for each waste stream during construction and operation are shown in Table 6.13.

Table 6.13: Estimated approximate annual mine waste generation during construction and operation

Waste Stream	Total Waste (tpa)		Waste Treatment
	Construction	Operations	
General Waste	1,550	625	Incinerator Landfill
Recyclable Waste	1,900	1,000	Sale Recycle
Putrescible Waste	1,900	800	Incinerator Landfill
Hazardous Waste	12	25	Incinerator Return to supplier (drums and batteries) Hazardous landfill
Timber Waste	2,950	12	Sale Recycle Biodegradation
Hydrocarbon Waste	155	230	Waste oil processing Offsite reuse Incineration Landfill

6.16.2. Port Facilities Area

The primary waste from the Port Facilities Area will be filtrate water that is to be discharged to the marine environment as discussed in Section 6.13.2. Minor quantities of solid waste will also be generated, comprising predominantly filter cloths and conveyor belt, packaging materials and office waste. Small amounts of hazardous waste may also be generated such as light bulbs, batteries and maintenance materials. These wastes will be managed through existing recycling and waste management facilities in Lae.

6.16.3. Outfall Area

The primary waste from the Outfall System will be the tailings, as discussed in Section 6.10.

The majority of general, recyclable and timber waste is expected to be generated during construction, including packaging materials and cleared timber and vegetation. During operations, as with the Port Facilities Area, small amounts of hazardous waste may also be generated and maintenance waste (lubricants, rags, metal offcuts) and will be managed through existing recycling and waste management facilities in Lae. Operations waste will be collected by staff and managed through the Port Facilities Area.

6.16.4. Infrastructure Corridor

It is anticipated that the mass of solid non-mineral waste generated from construction and operations of the Infrastructure Corridor will be relatively minor. Estimates of the waste, including likely clearance of vegetation and timber, will be made once the construction methods have been agreed and a construction contractor engaged.

6.16.5. Non-mineral Waste Management Facilities

A dedicated waste management facility for the Mine Area, including a landfill, will be located near the Watut Process Plant. Power and water reticulation will be provided to this facility. Wastes will be collected and sorted at the waste management facility and then managed according to waste type. The area will be hard paved and runoff collected for treatment if required.

A variety of waste management technologies and facilities may be employed to manage non-mineral wastes generated from the Mine Area including:

- Incinerators – A purpose built diesel-fired incinerator sited within the waste management facility is proposed to incinerate liquid and solid wastes including hydrocarbons and other combustible hazardous materials to reduce waste volumes. The landfill will be used for ash disposal. Additionally, smaller mobile units may be used throughout the Mine Area in preference to transporting wastes to the waste management facility.
- Metal crushing – A drum crusher will be employed in order to reduce the volume occupied by used 205L drums prior to shipment offsite. An oil filter crusher and can press will also be used to crush wastes to a smaller size, thereby reducing the frequency of bin/skip movements.
- Cardboard and plastic baler – A baler will crush and bale cardboard and plastic waste for removal from site for recycling.
- Wood chipper and/or mulcher – A wood chipping unit may be used for processing timber and vegetation. The mulch produced will be used in progressive rehabilitation and offered to nearby communities.
- Waste oil processing – Prior to reuse either on-site or offsite, basic waste oil processing may take place at the waste management facility. This will typically involve:
    - Settling and dewatering of the used oil
    - Filtering to remove solids present
    - Chemical treatment to demineralise the oil, or to remove heavy fractions
    - Some waste oils may be able to be processed for reuse onsite such as a fuel injection into the incinerator burn chamber
- Recycling – Where possible, waste materials such as paper, cardboard, glass and metals will be collected and prepared for recycling.
- Hydrocarbon skimmers – Hydrocarbon skimmer units will be placed in sump pits to separate hydrocarbon from water. Hydrocarbon liquid may then be stored for later incineration or offsite disposal.

The landfill will be designed and operated in general accordance with the intent of the DEC ECoP for Sanitary Landfill Sites, 2001 (Landfill Code of Practice), now adopted by CEPA. The landfill will be a Class 3 landfill under the Landfill Code of Practice and will incorporate the following design and operation considerations:

- Site selection in accordance with the principles outlined in the code and with consultation of relevant government agencies
- All-weather access
- Using an impermeable liner such as HDPE
- A leachate and gas collection and management system
- Stormwater management
- Final site landscaping and use following closure
- Landfill equipment such as compactor, excavator and dump truck
- Excess soil for waste cover
- Tracking of waste volumes and types landfilled

6.17. Road Traffic and Transport

6.17.1. Mine Area

As described in Section 6.4, once built, the Northern Access Road and the Mine Access Road will be the main access roads to the Mine Area for the construction and operations phases of the Project.

The Northern Access Road will be a public road. The Mine Access Road will be a private road, exclusively for the use of the WGJV and its invitees. Access to the Mine Access Road will be controlled.

The Project-related vehicle fleet will deliver fuel, food, materials and supplies. During the construction phase of the mine and supporting facilities, 30 trucks, per traveling direction per day, seven days a week are estimated. During the operations phase of the mine, traffic movements are significantly reduced, approximately five per travelling direction per day, seven days a week. Some loads may be opportunistically back loaded for example transporting selected wastes to Lae.

In most cases, personnel travelling to and from the Mine Area at the start and end of construction and operations shifts will be transported in WGJV buses.

Site readiness occurring prior to construction of the Northern Access Road will require materials such as cement to be transported to the Mine Area via the existing Demakwa Access Road. All existing roads are currently used by some local traffic (public motor vehicles and foot traffic) and will require upgrades to make the roads safe for these additional traffic movements.

6.17.2. Infrastructure Corridor

Equipment used for the construction of the Infrastructure Corridor is likely to include loaders, graders, excavators, prime movers, mechanical tree harvesters, 10t and 16t trucks, pipelayer sidebooms, bending machines, dump trucks and skid trucks. A range of preliminary access roads have been identified for accessing the right of way, following which equipment will operate within the right of way.

During construction, all personnel transport will be provided by the construction contractor. Travel routes to the various camps to the various work locations will be confirmed during the mobilisation phase. Only pre-approved roads and tracks will be permitted.

6.17.3. Port Facilities Area

Equipment used in the construction of the Port Facilities Area is likely to include forklifts, piling rigs, prime movers and cranes.

The nature of works within Port of Lae dictates that existing roads may at times be temporarily blocked (at least partially) or closed, or diversions put in place affecting both Project and non-Project vehicles. Prior to construction, a traffic control plan to address these issues in and around Port Facilities Area will be developed in consultation with port authorities and Lae Urban Local Level Government.

Once operational, the facility will be manned by approximately 10 staff who will travel to and from the area by light vehicle.

6.17.4. Outfall Area

Construction equipment used at the Outfall Area is likely to include 20t and 40t truck and trailers, rough terrain mobile cranes, diesel-powered air compressors and welding machines, working platforms and scaffolding, and miscellaneous jacks, high lifts and hydraulic jacks. Graders and mechanical tree harvesters are also likely to be used to clear the site.

As for the Infrastructure Corridor and the Port Facilities Area, construction workers will be transported to the Outfall Area by the construction contractor. Priority will be given to buses over light vehicles to reduce traffic impacts on the local community.

Once operational, the Outfall System will be inspected regularly by staff based at the Port Facilities Area. Typically, light vehicles will be used to access the area.

6.18. Resettlement

While WGJV is designing the Project to minimise the requirement displacement, there will likely be a need for some households to physically relocate due to Project activities or impacts. Within the SML, the villages of Hekeng, Nambonga and Venembele are intended to be relocated. The number of households in these villages are 53, 19 and 73, respectively based on a household census conducted by Coffey in 2017 (Appendix T, Socioeconomic Baseline).

WGJV has established a Community Resettlement Committee with each of the three affected villages, whereby an engagement process commenced in mid-2016. The representatives on each of the three committees have been selected by their respective communities and consist of a cross section of the villagers, in terms of interest groups and clans. The initial focus of discussions has been on the establishment of communications structures and the identification of suitable replacement land for the village sites and associated land areas for livelihood restoration.

A number of initial options have been identified for each of the villages: Venembele at Nongokwa, Nambonga at Kwepkwep/Tivgi and Hekeng at Old Hengambu (see Figure 6.3 which also indicates possible access road routes to link the Resettlement Road with the Watut Services Road at Madzim).

Individual households which may be affected along the Infrastructure Corridor route have not yet been identified, but relocation of households will be minimised by adjusting the route during detailed design.

Under the WGJV Resettlement and Displacement of People Standard COM04 and the Resettlement Policy Framework developed for the Project, resettled households will be entitled to compensation for loss of assets, provision of adequate replacement housing with security of tenure, and assistance to quickly and sustainably re-establish livelihoods and standards of living. Infrastructure provision will also be a consideration when resettling Hekeng, Nambonga and Venembele.

Further details of the WGJV's Resettlement Policy Framework are provided in Chapter 18, Socioeconomic Impact Assessment, and Attachment 4, Social Management Plan).

6.19. Workforce

6.19.1. Construction Workforce

Due to the geographic spread of the proposed Project infrastructure, separate construction teams will be required at a number of sites. The construction workforce across these areas is estimated to be approximately 2,500 full time equivalent workers of approximately two thirds will be in the Mine Area.

A key focus for the WGJV will be the employment of appropriately qualified PNG citizens, with priority given to landowners of local districts in the Project Area.

6.19.2. Operations Workforce

The WGJV expects the Project to employ around 850 full time equivalent workers, including both employees and contractors, during the operations phase and further indirect jobs created in the region. The operations workforce will work a variety of rosters dependent on their role and home location.

The progressive localisation of jobs, both in terms of the proportion of PNG workers and, more specifically, the proportion of PNG workers from Morobe Province, will contribute to rising employment and wages levels within the Province throughout the LOM. Employment and training opportunities will be directed to maximising the proportion of PNG workers over time. The target is for 85% of operations jobs to be held by PNG citizens within five years of the commencement of operations.

6.19.3. Operating Hours

The operating hours of Project facilities are as follows:

- Mine: 24 hours per day, 365 days per year, apart from scheduled and unscheduled shutdowns
- Watut Process Plant: short 'campaigns' (e.g., seven days on, seven days off) during ramp-up in Years 1 and 2 and expected 365 days per year at full production, with the exception of scheduled and unscheduled shutdowns
- Fuel pipeline: 24 hours per day with regular pigging operations on an as required basis
- Concentrate filtration plant: 24 hours per day, 365 days per year, subject to scheduled and unscheduled maintenance shutdowns
- Mix/de-aeration tank: intended 365 days per year, excluding scheduled and unscheduled shutdowns

6.20. Cleaner Production and Energy Balance

The greatest energy demand for the Project is estimated to be from the Watut Process Plant, followed by the ventilation system refrigeration plant, and mine dewatering and mine water treatment.

The Watut Process Plant, dewatering and refrigeration components will be the subject of future analysis to determine the most appropriate technologies and processes with regard to energy efficiency. In particular, process and mechanical detailed design and engineering will consider the energy constraints and appropriate size of equipment.

The energy-efficient building and structure design measures to be incorporated include:

- Insulated walls, ceilings and roofs of office, administration and accommodation buildings
- Increased light reflectance on walls and ceilings
- Energy-efficient glass or film and shade windows from direct sun
- Non-essential services grouped on the same circuits to allow these circuits to be remotely switched off during periods of peak demand

Energy efficiency opportunities will be under continual review during Project design, construction and operations.

6.21. Closure

A Conceptual Closure and Rehabilitation Plan has been prepared as part of this EIS (Attachment 2, Conceptual Closure and Rehabilitation Plan). This plan details the currently proposed closure strategies for the environmental and social aspects of the Project. The primary objectives will be to ensure the site is left safe and stable in the long-term and to assist Project-affected communities to access long-term, sustainable opportunities post-closure.

Stakeholder consultation for closure will be part of WGJV's broader stakeholder consultation refined during the Project's operation phase. This will ensure that interests and concerns of stakeholders are considered during the closure planning process.

Eight closure domains – a set of Project elements or landforms with a common set of management/rehabilitation requirements and closure objectives – are in the Conceptual Closure and Rehabilitation Plan. The domains are:

- Mine workings and openings
- Subsidence zone and subsidence zone lake
- Waste rock dumps and ore stockpile pads
- Borrow pits, quarries and river gravel extraction sites
- Mine Area Infrastructure and Industrial Areas
- Sediment control and other water management infrastructure
- Linear infrastructure
- Port Facilities Area, outfall system and the DSTP tailings footprint

In addition, the socioeconomic requirements for mine closure are also outlined in the Conceptual Closure and Rehabilitation Plan. The specific implementation actions for the closure of each domain are listed in Attachment 2, Conceptual Closure and Rehabilitation Plan.

The general sequence of the closure phase will be:

- Undertake further stakeholder consultation (as part of the WGJV's ongoing engagement program)
- Complete operations, including processing of last ore and flushing of tailings management system with clean water
- Make equipment safe, including decontamination if required
- Dismantle infrastructure (with the exception of sub-surface pipelines which will remain in situ) and bury or remove offsite for disposal
- Transfer assets or infrastructure to third parties (as applicable and agreed)
- Re-shape landforms (where practicable) and ensure that erosion control measures are implemented
- Reinstate topsoil
- Revegetate
- Carry out monitoring and amelioration as required

Refinement of closure risks, objectives and criteria will occur during operations through stakeholder engagement, collection of empirical data and improvement of closure predictions. This will inform subsequent iterations of the Conceptual Closure and Rehabilitation Plan, which will become progressively more detailed.

6.22. References

Clean TeQ. 2017. 532-4600-PR-REP-30001 Wafi Golpu Mine Water Treatment HDS and DeSALx® Piloting Report.

CSIRO. 2017. Geochemical and Ecotoxicological Characterisation of Tailings.

DEC. 1997. Environmental Code of Practice for Vehicle/Machinery Workshops and Petroleum (Hydrocarbons) Storage/Resale/UsageSites.

Itasca. 2016. Wafi Golpu - Feasibility Study. Numerical Assessment of Caveability, Excavation Stability and Gravity Flow.

Itasca. 2018. Numerical Assessment of Caveability and Subsidence for BC44, BC42 and BC40. DRAFT. Prepared for Wafi-Golpu Joint Venture (WGJV). Victoria. Australia.

Lupo, J. 1998. Large-scale surface disturbances resulting from underground mass mining. International Journal of Rock Mechanics and Mining Sciences, 35(4-5) (Paper No. 25.).

ToxConsult. 2017. Dangerous Goods and Transport Classification for Wafi-Golpu copper concentrate. Prepared by ToxConsult Pty Ltd for Wafi-Golpu Joint Venture.

Van As, A., Davison, J. & Moss, A. 2003. Subsidence Definitions for Block Caving Mines.