Attachment 2

Conceptual Closure and Rehabilitation Plan

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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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Development of Project subject to Approvals, Further Studies and Market and Operating Conditions

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.

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Non-IFRS Financial Information

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.

Ore Reserves and Mineral Resources Reporting Requirements

As an Australian Company with securities listed on the Australian Securities Exchange (ASX), Newcrest is subject to Australian disclosure requirements and standards, including the requirements of the Corporations Act 2001 and the ASX. Investors should note that it is a requirement of the ASX listing rules that the reporting of Ore Reserves and Mineral Resources in Australia comply with the 2012 Edition of the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (the JORC Code) and that Newcrest's Ore Reserve and Mineral Resource estimates comply with the JORC Code.

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.

Conceptual Closure and Rehabilitation Plan

LIST OF ABBREVIATIONS

Abbreviation	Description
%	percent
AMD	acid and metalliferous drainage
BC	block cave (abbreviated only where referring to specific block cave, e.g., BC 44)
CEO	Chief Executive Officer
CEPA	Conservation and Environment Protection Authority
DSTP	deep sea tailings placement
EHS	environmental, health, and safety
EIS	environmental impact statement
IFC	International Finance Corporation
km	kilometre
km2	square kilometre
L/s	litres per second
LHD	load-haul-dump vehicle
LLG	Local Level Government
m	metres
m3	cubic metres
mASL	metres above sea level
mbgl	metres below ground level
mm	millimetres
MRA	Mineral Resources Authority
mRL	metres reduced level
Mtpa	million tonnes per annum
NAF	non-acid forming
NGO	non-governmental organisation
PAF	potentially acid forming
pH	power of hydrogen (acidity or alkalinity of a solution)
PMF	Probable Maximum Flood
PNG	Papua New Guinea
WGJV	Wafi-Golpu Joint Venture

GLOSSARY

Term	Description
block caving	An underground hard rock mining method that involves undermining an ore body, allowing it to progressively collapse under its own weight as a means of breaking and extracting the ore.
closure	Final stage following the cessation of mining and processing and includes progressive rehabilitation, decommissioning, post closure monitoring and maintenance, and relinquishment.
decline	A sloping underground tunnel excavated for mobile equipment access from surface or from level to level.
decommission	Demolition and disposal of all mining, mineral processing and ancillary infrastructure and services that are no longer required or used.
dispersive soils	Structurally unstable soils that are particularly vulnerable to erosion by water
drawpoint	An opening at the base of the block cave where descending broken rock is removed.
environmental impact statement (EIS)	A document that provides a comprehensive assessment of potential environmental and social impacts (or benefits) associated with a project, in accordance with Section 53 of the PNG *Environment Act 2000*.
load-haul-dump	The process of loading, hauling and dumping of either waste rock or ore.
post-closure monitoring	Process of collecting, analysing and interpreting monitoring data post-closure to determine if the objectives and closure criteria have been met.
progressive rehabilitation	The process of rehabilitating those portions of the disturbed sites that are no longer necessary for the immediate operating requirements of the mine with the aim of returning the land to an agreed post-mining land use.
relinquishment	When monitoring has provided evidence that the objectives and closure criteria have been met to the satisfaction of the regulatory authority, the company is formally released from all obligations with respect to associated tenements, with the regulators or a third party assuming responsibility for the leases.
subduction	An area of convergence between a sinking tectonic plate and an overriding plate.
ventilation shaft	A vertical or sub-vertical passage used in an underground mine to allow the flow of air either into, or out of the mine.

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1. INTRODUCTION

1.1. Background

Wafi Mining Limited and Newcrest PNG 2 Limited (the WGJV Participants) are equal participants in the Wafi-Golpu Joint Venture (the WGJV). The WGJV Participants are currently investigating the feasibility of constructing, operating and (ultimately) closing 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 "Project").

The proposed underground copper-gold mine will be located beneath Mt Golpu, approximately 300 kilometres (km) north-northwest of Port Moresby and 65km southwest of Lae in the Morobe Province of the Independent State of Papua New Guinea (PNG). Related support facilities include access roads to the mine and pipelines from the mine to the Port of Lae and to new coastal facilities near the village of Wagang.

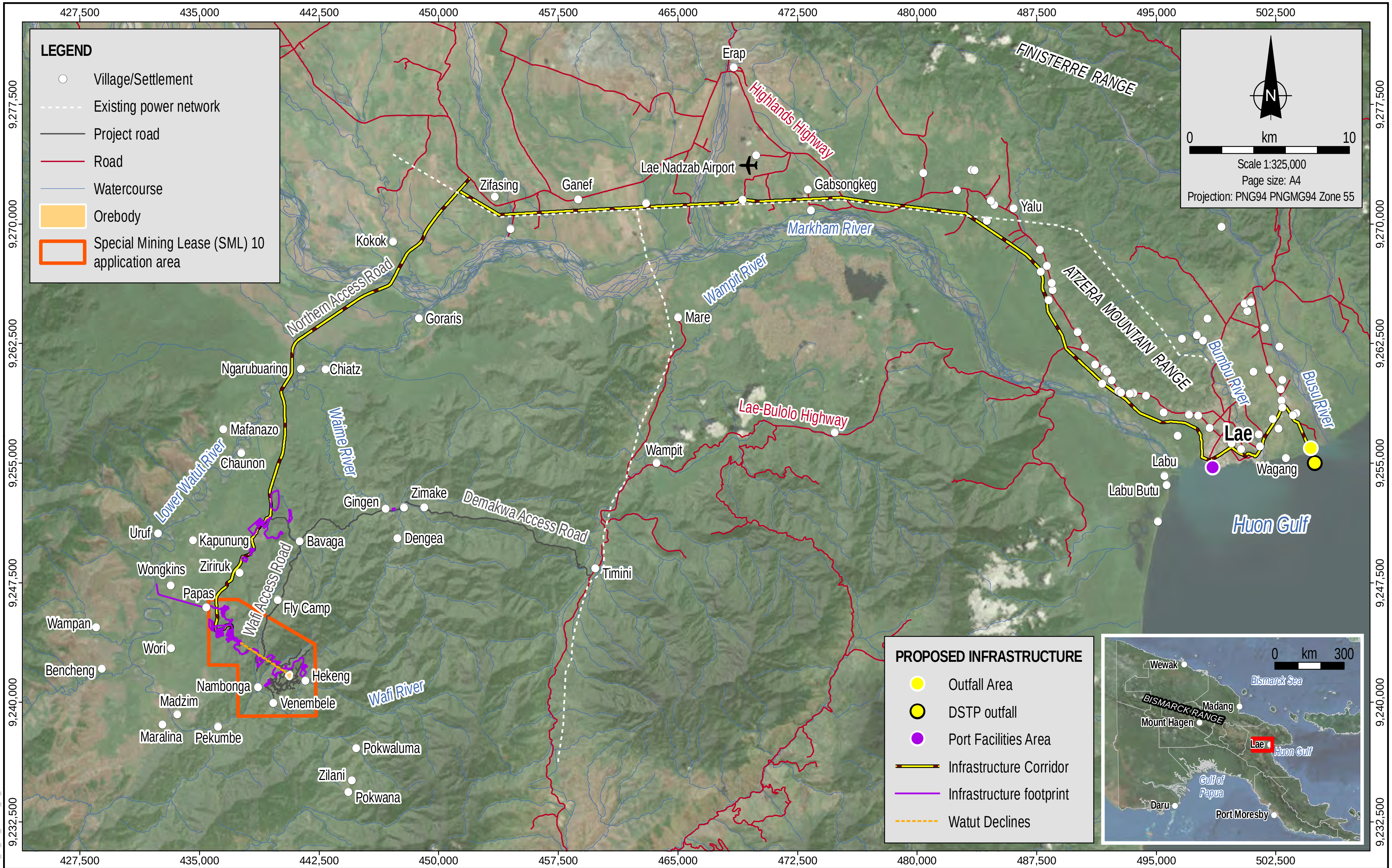
Geographically, the Project can be divided into three main areas, which together form the Project Area:

- **Mine Area**. The area encompassing the proposed block cave mine and nearby infrastructure, including the portal terrace, Watut and Nambonga declines, waste rock dump, Watut Process Plant, any 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 Project infrastructure linking the Mine Area and the proposed Coastal Area, being corridors for pipelines, roads and 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 Port Facilities Area and the Outfall Area:
  - Port Facilities Area. The area encompassing the proposed facilities located at the Port of Lae, including the concentrate filtration plant and materials handling, storage, ship loading facilities and filtrate discharge pipeline. This area may in the future need to include fuel oil handling and storage facilities.
  - Outfall Area. The area encompassing the Outfall System (including mix/de-aeration tank, seawater intake pipelines and DSTP outfall pipelines), pipeline laydown area, choke station, access track and parking turnaround area.

The location of the main Project infrastructure is shown in Figure 1.1 and Figure 1.2 and is described further in Section 6.

1.2. Overview of this Plan

This Conceptual Closure and Rehabilitation Plan has been prepared to inform the Wafi-Golpu Project Environmental Impact Statement (EIS).



Source:
Power network, SML and orebody from WGJV.
Villages, infrastructure and project roads from WGJV and Coffey.
Roads and watercourses from NSO.
Imagery from ArcGIS Online (capture date unknown).

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Date: 08.06.2018
Project: 754-ENAUABTF100520DD
File Name: 0520DD_10_Att6_F01.01_GIS

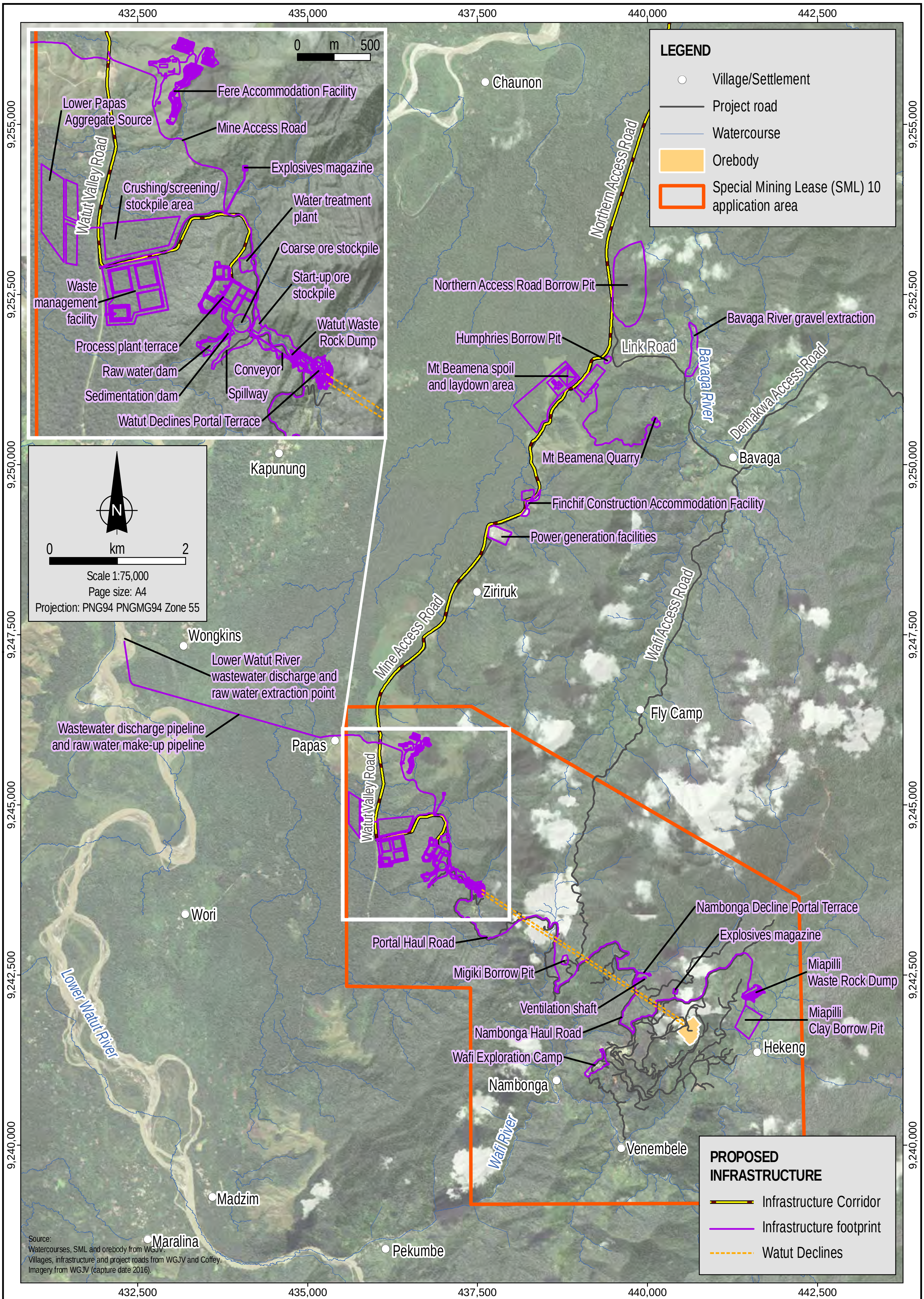
WAFI-GOLPU JOINT VENTURE

Wafi-Golpu Project

General arrangement of proposed Project

Figure No: 1.1

MXD Reference: 0520DD_10_BM_GIS001_v0_11



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Date: 23.04.2018
Project: 754-ENAUABTF100520DD
File Name: 0520DD_10_Att6_F01.02_GIS

WAFI-GOLPU JOINT VENTURE

Wafi-Golpu Project

General arrangement of proposed Mine Area

Figure No: **1.2**

The purpose of this Conceptual Closure and Rehabilitation Plan is to:

- Provide a conceptual planning framework for mine closure
- Identify preliminary closure objectives and outline how closure is proposed to be implemented
- Outline how key stakeholders are proposed be engaged during the closure planning process

This plan:

- Provides an overview of the Project
- Describes the environmental and social setting
- Defines a proposed set of closure principles and objectives
- Identifies key risks to the biophysical and social environment associated with planned or unplanned closure of the Project
- Describes conceptual closure actions proposed during decommissioning through the post-closure period
- Identifies key stakeholders and describes the proposed engagement to be undertaken during closure planning
- Includes a preliminary closure monitoring and evaluation program

In addition to outlining the decommissioning and rehabilitation activities proposed to be undertaken following the cessation of mining and processing, this plan also covers rehabilitation intended to be undertaken progressively throughout the mine life. Proposed progressive rehabilitation measures are also included within the Wafi-Golpu Project Environmental Management Plan (EMP).

The conceptual closure and rehabilitation activities described in this plan are consistent with the principles contained in the draft PNG Mine Closure Policy and Guidelines (2005) and have been developed in consideration of relevant regulatory requirements or selected international guidelines, as described in Section 2.

1.3. Closure Domains

To describe mine rehabilitation and closure requirements for the Project, specific closure domains have been defined. A domain is a set of project elements or landforms with common management/rehabilitation requirements and closure objectives.

The following domains are considered in this Conceptual Closure and Rehabilitation Plan:

- Mine workings and openings
- Block cave subsidence zone and subsidence zone lake
- Waste rock dumps and ore stockpile pads
- Borrow pits, quarries and river gravel extraction
- 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, this Conceptual Closure and Rehabilitation Plan considers the socioeconomic requirements for mine closure, including the effect of closure on Project personnel.

2. REGULATORY FRAMEWORK

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

2.1. Legislation and Policy of Papua New Guinea

2.1.1. Mining Act 1992

The principal regulatory instrument governing mine closure in PNG is the *Mining Act 1992*, which is administered by the Mineral Resources Authority (MRA). The *Mining Act 1992* contains mechanisms for managing mine rehabilitation and closure requirements, typically through conditions placed on mining leases.

2.1.2. Environment Act 2000

The framework for mine closure established under the *Mining Act 1992* is supported and complemented by legal provisions in the *Environment Act 2000*, which is administered by the Conservation and Environment Protection Authority (CEPA). The *Environment Act 2000* provides the legal framework for the identification of environmental values and the protection of these through the:

- Establishment of environmental policies and standards
- Control of implementation of development activities
- Regulation of discharges to air, land or water
- Regulation of the use and transmission of water
- Establishment of a regulatory framework to prevent unlawful environmental harm and pollution
- Imposition of levies or financial securities to encourage compliance and support the attainment of environmental objectives

The *Environment Act 2000* provides a three-tier process for dealing with activities with the potential to cause environmental harm. Activities are classified as Level 1, Level 2 or Level 3. Level 3 activities are those which have a higher risk of causing environmental harm, based on their nature and scale, and are subject to a full environmental assessment process. A Level 3 environment permit will be required for the Project and this EIS has been prepared to support the application for a Level 3 environment permit from the PNG government.

While not explicitly addressing mine rehabilitation or closure, the *Environment Act 2000* has an important influence on mine closure through the environment permit application, EIS and environmental management plans submitted in support of permit applications. The content of these documents informs government's decision to approve the Project and will be supplemented by conditions in approvals and permits issued under the *Environment Act 2000* and associated subordinate legislation.

Environmental quality standards and guidelines developed pursuant to the *Environment Act 2000* (e.g., the PNG Environment (Water Quality Criteria) Regulation 2002) must also be taken into account when developing mine rehabilitation and closure plans.

2.1.3. Mine Closure Policy and Guidelines

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

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

In addition, six new mining policies are under consideration (National, 2017) by the PNG National Executive Council, including a policy on rehabilitation and mine closure. Any additional closure requirements applicable to the Project that come into effect during the mine life will be reviewed and incorporated into the WGJV's closure planning processes.

2.1.4. Environmental Code of Practice – Mining Industry (2000)

Section 38 of the *Environment Act 2000* provides for the promulgation of environmental codes of practice, for the purpose of providing guidance on ways to achieve compliance with the objectives of the *Environment Act 2000*. Codes of practice are voluntary, unless made legally binding through the inclusion of a permit condition requiring adherence to the code.

A Code of Practice for the Papua New Guinea Mining Industry was issued in 2000. While targeted at construction and operation of mines, the Environmental Code of Practice – Mining provides general guidance for environmental management that is relevant to closure and the post closure phases, such as the management of mineral wastes and acid and metalliferous drainage.

2.2. International Policies and Guidelines

2.2.1. International Council of Mining and Metals

The International Council on Mining and Metals (ICMM) (of which Newcrest Mining Limited, one of the Wafi-Golpu Joint Venture Participants, is a member) has developed a Sustainable Development Framework. The framework comprises three elements: a set of ten principles (including supporting position statements), public reporting and independent assurance.

The ten sustainable development principles are (ICMM, 2015):

1. Apply ethical business practices and sound systems of corporate governance and transparency to support sustainable development
2. Integrate sustainable development in corporate strategy and decision-making processes
3. Respect human rights and the interests, cultures, customs and values of employees and communities affected by our activities
4. Implement effective risk-management strategies and systems based on sound science and which account for stakeholder perceptions of risks
5. Pursue continual improvement in health and safety performance with the ultimate goal of zero harm
6. Pursue continual improvement in environmental performance issues, such as water stewardship, energy use and climate change
7. Contribute to the conservation of biodiversity and integrated approaches to landuse planning

8. Facilitate and support the knowledge-base and systems for responsible design, use, re-use, recycling and disposal of products containing metals and minerals
9. Pursue continual improvement in social performance and contribute to the social, economic and institutional development of host countries and communities
10. Proactively engage key stakeholders on sustainable development challenges and opportunities in an open and transparent manner. Effectively report and independently verify progress and performance

While all of these principles impact on mine closure planning and procedures to some degree, principle six – to pursue continual improvement of environmental performance issues – provides specific implementation guidance about mine closure, as follows (ICMM, 2015):

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

In addition to the ten sustainability principles, ICMM has developed a toolkit for planning for integrated mine closure (ICMM, 2008b) that provides practical guidance for sustainable mine closure. The document promotes a risk- and opportunity-based approach through an iterative process for closure planning.

2.2.2. Enduring Value

To give practical and operational effect to the ICMM commitments, the Minerals Council of Australia (MCA) (of which Newcrest Mining Limited is an associate member) developed Enduring Value – The Australian Minerals Industry Framework for Sustainable Development (MCA, 2005; MCA, 2015). Enduring Value is designed to assist minerals sector managers to implement the sector's commitment in a practical and operational manner that is targeted at the site level. Enduring Value provides implementation guidance on the operation of elements imbedded within each sustainability principle, and cross-referencing between the elements.

2.2.3. Other Standards and Guidelines Relevant to Closure

The International Finance Corporation (IFC) Sustainability Framework outlines eight Performance Standards on Environmental and Social Sustainability. The principles and objectives of the Performance Standards are broadly applicable to mine closure, but do not discuss mine rehabilitation or closure in detail. The IFC has promulgated the following guideline documents relevant to the assessment and management of mineral wastes, a key consideration for mine closure at the Project:

- Environmental, Health, and Safety Guidelines – Mining (2007)
- Environmental, Health, and Safety (EHS) Guidelines General EHS Guidelines: Environmental Contaminated Land (2007)

Other key international guidelines that contain recommendations relevant to mine rehabilitation and closure include:

- Strategic Framework for Mine Closure (ANZMEC and MCA, 2000)
- Mine Rehabilitation, Leading Practice Sustainable Development Program for the Mining Industry (DITR, 2016b)
- Preventing Acid and Metalliferous Drainage, Leading Practice Sustainable Development Program for the Mining Industry (DITR, 2016c)
- Stewardship, Leading Practice Sustainable Development Program for the Mining Industry (DITR, 2006)

Technical guidelines relevant to specific aspects of mine rehabilitation and closure exist, for example:

- Global Acid Rock Drainage Guide (INAP, 2014)
- International Primer on Ecological Restoration (SER, 2004)

2.3. Wafi-Golpu Joint Venture Policies and Standards

The WGJV Sustainable Business Management System pertains to all phases of development, including mine closure. Two policies within the Sustainable Business Management System that are of particular relevance to closure are the Environment Policy and the Social Responsibility Policy.

The Environment Policy provides that WGJV will comply with applicable statutory and regulatory requirements for environmental management, and rehabilitate areas disturbed by mining in accordance with WGJV's Environmental Management Standards. The WGJV standards associated with the Environment Policy most relevant to mine rehabilitation and closure are:

- Rehabilitation and closure (ENV05)
- Waste rock management (ENV02)

The WGJV Social Responsibility Policy seeks to benefit communities through sustainable socioeconomic programs. In relation to closure, the objective is to leave an enduring benefit after closure of operations (refer to Sustainable Business Management System standard – Community Development and Support (COM03)).

The Wafi-Golpu Joint Venture has developed an environmental and social integrated management system to manage the predicted environmental, socioeconomic and cultural heritage impacts, and other risks, of the Project. The term 'integrated management system' refers, primarily, to the Environmental and Social Management Framework.

The Environmental and Social Management Framework has regard to:

- Corporate policies, standards and systems (including the Investment Management Framework and Sustainable Business Management System).
- Potential environmental, socioeconomic and cultural heritage impacts and risks and opportunities as identified through the preparation of the EIS and Feasibility Study Update.
- Other Project planning activities required by the Independent State of PNG to support the WGJV's application for a special mining lease for the Project (principally, investigations into workforce, supply and procurement and employment and training).

Management plans that constitute the Environmental and Social Management Framework will identify environmental, socioeconomic and cultural heritage opportunities and potential impacts and risks and the measures proposed to be implemented to manage them. Plans will be implemented, where appropriate, through a series of standard operating procedures as well as agreed requirements arising from the State of PNG's assessment of this EIS, and any conditions of approval for the Project.

Further details of the integrated management system and the Environmental and Social Management Framework is provided in Chapter 23, Integrated Management System, in the EIS (WGJV, 2018).

3. PROJECT SETTING

3.1. Biophysical Setting

3.1.1. Geographic Setting

The Mine Area is located on the northern side of the Owen Stanley Ranges of PNG, approximately 65km southwest of Lae, within the Watut River catchment. The elevation of the Mine Area ranges from approximately 100 metres above sea level (mASL) in the Lower Watut River area to 380mASL where the proposed ventilation shaft is located. 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 Lower Watut River valley (Figure 1.2), following the proposed Mine Access Road and Northern Access Road. It crosses both the Lower Watut and Markham rivers, to a point just south of the Highlands Highway, where the corridor intersects the PNG Power high-voltage transmission line (Figure 1.1). At this point, the proposed pipelines diverge from the Northern Access Road to travel east following the PNG Power transmission line to approximately 3km west of the settlement of Yalu on the Highlands Highway. There, the Infrastructure Corridor deviates from the PNG Power 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.

While the proposed concentrate and fuel pipelines terminate at the Port Facilities Area at the Port of Lae, the Infrastructure Corridor continues through Lae to the Outfall Area, located between the Wagang settlement and mouth of the Busu River. Collectively, the Port Facilities Area and the Outfall Area are referred to as the Coastal Area.

Further information on the geographic setting for the Project is provided in Chapter 6, Project Description, of the Project EIS (WGJV, 2018).

3.1.2. Climate

Papua New Guinea's climate is dominated by two main seasons: the northwest monsoon (wet) season which occurs annually between November and April and the southeast monsoon (dry) season, occurring annually between May and October.

Historical meteorological data has been collected intermittently from the automatic weather station on Mt Golpu and from a manual rainfall gauge at Wafi camp since 1990.

The data obtained indicates that the highest rainfall occurs in the wet season between December and April. Annual recorded rainfall was highest in 1995 (3,440mm) and the average annual rainfall is 2,836mm.

Regional evaporation is generally constant throughout the year, ranging from 1,320mm/year to 2,040mm/year at Bulolo and 2,100mm/year at Lae airport. The average annual evaporation rate for the Project site is approximately 2,000mm.

Based on the mean annual rainfall total recorded at Wafi Camp, and the estimated annual evaporation, the Mine Area experiences a water surplus where rainfall exceeds evaporation by approximately 800mm/year.

Further information on the climatic setting for the Project is provided in Chapter 8, Physical and Biological Environment Characterisation, of the Project EIS (WGJV, 2018).

3.1.3. Geology

The Project lies in a block of deformed Upper Mesozoic to Middle Miocene period metasedimentary to sedimentary rocks, cut by Miocene-Pliocene calc-alkaline dioritic intrusives.

The Golpu Porphyry copper-gold orebody consists of multiple, diorite porphyries (i.e., volcanic rocks with coarse crystals within a finer grained matrix) bearing hornblende (an amphibolite mineral), intruded into host sediments of the Owen Stanley Metamorphics. The orebody originates from volatile magma that ascended through the Earth's crust, and is approximately 800m by 400m, extending from 200 metres below ground level (mbgl) to more than 2,000mbgl. Within the Golpu deposit are a porphyry core, a high sulphidation hydrothermal system surrounding the core and a mixed zone where these two systems combine. The porphyry system is mineralised with gold, copper, silver and molybdenum. In the outer hydrothermal zone of the orebody, gold is associated with pyrite and chalcopyrite.

Further information on the geological setting for the Project is provided in Chapter 8, Physical and Biological Environment Characterisation, of the Project EIS (WGJV, 2018).

3.1.4. Seismicity

Papua New Guinea is bounded by several major tectonic plates and is one of the most seismically active regions in the world (World Bank, 2008). To the north of the Owen Stanley Ranges, tectonic plate movements thrust the leading edge of PNG over the Pacific Plate, leading to rotation and compression in the Project Area. There are two main sources of earthquakes that could occur in the vicinity of the Project Area:

- Crustal events that occur in areas away from plate contacts and have produced earthquakes up to magnitude 7.7 (SRK, 2007).
- Subduction events that occur due to the subduction of the Pacific Plate at the interface between the Pacific Plate and the overriding Indo-Australian Plate, or in the intra-slab zones within the subducting Pacific Plate; these events have produced earthquakes up to magnitude 8.4 (SRK, 2007).

Further information on the regional seismicity is provided in Chapter 8, Physical and Biological Environment Characterisation, of the Project EIS (WGJV, 2018).

3.1.5. Mine Materials Geochemistry

Geochemical characterisation of mine materials has revealed that almost all of the ore and much of the waste rock is predicted to be potentially acid forming (PAF). As a result, waste rock will require appropriate management and as mining progresses and the zone of subsidence increases, mine water quality is expected to deteriorate and become acidic with elevated concentrations of dissolved metals, particularly zinc, copper, iron and manganese.

The shape of the Golpu orebody is near vertical and extends from 200mbgl to a depth of more than 2,000mbgl. Underground mining by block caving is proposed to extract the ore. Access to the mine workings is proposed via declines (both Watut and Nambonga) and a ventilation shaft and these will generate waste rock that will be segregated into NAF and PAF components and both will be managed separately. Block cave mining will not result in the production of waste rock per se, but will cause a subsidence zone of fractured rock to develop that will propagate to surface, and when formed will allow the ingress of water and, to a lesser extent, oxygen.

Mined ore will be stockpiled temporarily on surface before being processed.

The declines, ventilation shaft, block caves, rock subsidence zone and ore stockpile will increase the exposure of PAF rock to both water and oxygen, and that could lead to acidification of contact water and dissolution of metals.

3.1.5.1. Waste Rock Characterisation

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.

Based on geochemical analysis, 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 non-acid forming (NAF). 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 from the ventilation shaft is likely to be predominantly PAF. As a precautionary measure, waste rock will be geochemically characterised ahead of abstraction by means of ‘cover’ drilling along the decline and ventilation shaft alignment.

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.

Table 3.1 define the waste rock generated from the declines and ventilation shaft and the estimated approximate volumes and tonnages of NAF and PAF material produced.

Table 3.1: 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
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**

Further information on the characterisation of waste rock for the Project is provided in Chapter 6, Project Description, of the Project EIS (WGJV, 2018).

3.1.5.2. Rock Subsidence Zone

Most of the rock within the subsidence zone is expected to be argillic and advanced argillic rock types which are known to be predominantly PAF. Oxidation of the reactive sulphides within these rock types is predicted to occur in the presence of air and water and acid rock drainage is expected to occur. During operations, this acidic water will drain into the mine workings and surplus mine water will be treated if required to meet regulatory permit conditions before reuse or disposal.

At closure, the PAF material in the subsidence zone will remain in place and, in the long term, is expected to continue to oxidise until all the sulphide minerals have been oxidised or until oxidation is precluded, i.e., the PAF material is permanently submerged underwater.

Further information on the subsidence zone is provided in Chapter 6, Project Description, of the Project EIS (WGJV, 2018).

3.1.5.3. Tailings Characterisation

CSIRO conducted geochemical and ecotoxicological characterisation of two tailings samples produced from a pilot flotation testwork program in October 2017 (Adams, et al., 2018). The two samples comprised approximate porphyry and metasediment compositions of 90:10 and 25:75, representing the likely outlying ratios of the two principal rock types extracted during the life of mine.

The tailings 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.

Further information on the characterisation of tailings for the Project is provided in Chapter 6, Project Description, of the Project EIS (WGJV, 2018).

3.1.5.4. Soil Resources

Information describing the soils across the Project Area is derived from the PNGRIS dataset. Soils across the Project Area comprise five main geological units. Visual inspection and physical/chemical analysis of soils in the Mine Area (KCB, 2013) provides further detail of the soil classifications used in PNGRIS. The geological units and their particular properties based on investigations in the Mine Area are alluvium, colluvium, residual, slopewash and topsoils. Soil conditions throughout the site are fairly homogenous; while the test results indicated the soils are non-dispersive, erosion is still a risk due to the high rainfall.

Soils within the Mine Area sampled during baseline testing already have elevated levels of some elements prior to mining – including antimony, arsenic, lead, selenium and zinc – which is typical of a highly mineralised zone. The results of testing indicate that soils from around the ventilation shaft would have a low pH (2.7), and leachate and water-soluble concentrations of arsenic, lead, selenium and zinc would be above detection limits, whereas soils around the portal terrace, process plant terrace and Fere Accommodation Facility would have an alkaline pH (8.7) leachate and water-soluble concentrations of arsenic and zinc above detection limits (KCB, 2013).

Further information on soils in the Project Area is provided in Chapter 8, Physical and Biological Environment Characterisation, of the Project EIS (WGJV, 2018).

3.1.6. Surface Water

The main watercourses within the Project Area include (Figure 3.1):

- Lower Watut River
- Markham River
- Wafi River
- Watercourses on the eastern floodplain of the Lower Watut River
- Bavaga River
- Busu River

The Lower Watut River is a large, turbid river that bisects a broad floodplain. It drains an area of approximately 4,860km^2, including approximately 4,161km^2 upstream of the confluence with the Wafi River. The total estimated length of the Lower Watut River is between 157km and 224km and the river drains the catchment in a generally northern direction to its confluence with the Markham River.

The Markham River, a large, fast flowing and turbid river, is the fourth largest river in PNG, with a total catchment area of approximately 13,000km^2 (including the Lower Watut River catchment). The river originates in the Finisterre Range and flows approximately 170km before discharging into the Huon Gulf at Lae.

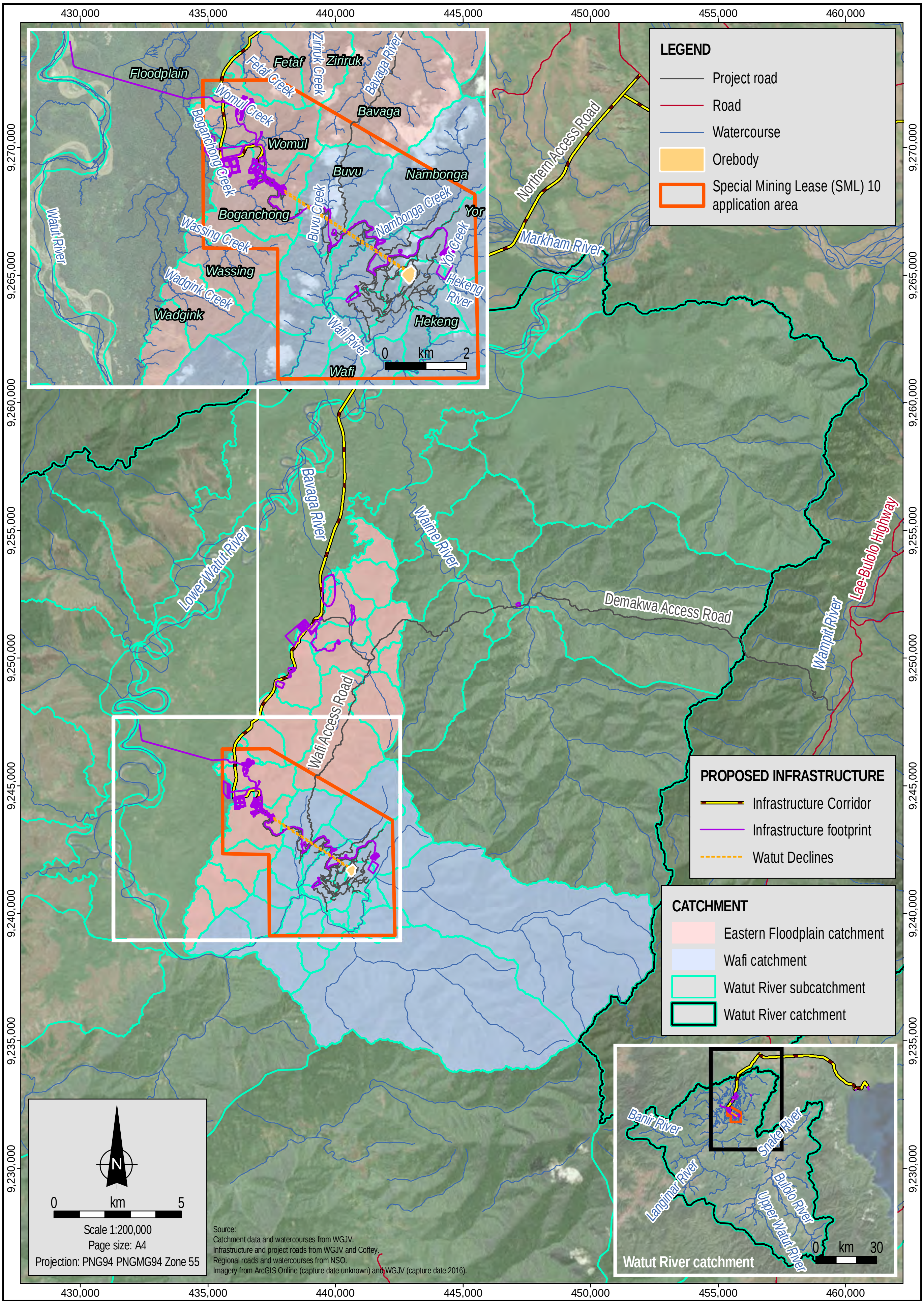
The Wafi River catchment is located in the middle section of the Watut River basin and has a catchment area of 120km^2. The catchment has a mountainous terrain with an elevation of 760m at Mt Golpu, with deeply incised valleys and steep valley walls of up to 45 degrees that are largely forested.

The Lower Watut River floodplain area has numerous small streams draining the steep catchments to the west and east. Some sub-catchments to the east of the floodplain fall within the Mine Area and Infrastructure Corridor, and these include the Bavaga River and Bobul, Kufikasep, Finchif, Ziriruk, Fetaf, Womul, Boganchong, Wassing and Wadgink creeks. The eastern floodplain catchments are small in area (1 to 5km^2) and prone to flash flooding, but individually contribute a small proportion to the total Lower Watut River flow.

The Bavaga River is one of the larger sub-catchments in the eastern Watut River floodplain, with a total area of 28km^2. The Bavaga River flows into wetlands within the Watut River floodplain, which then flows into the main Watut River channel.

The Busu River has a relatively small and very steep catchment area characterised by short-duration flash flood events, with high stream power. It is one of a number of heavily braided and fast flowing rivers that drain a combined catchment area of about 4,000km^2 in the steep and rugged Finisterre Range. Particularly during frequent flood events, large amounts of coarse-grained sediment are transported directly to the sea. The mouth of the Busu River is located immediately east of the Outfall Area. The mouth of the Busu River is located immediately east of the Outfall Area.

Further information on surface water in the Project Area and its existing use is provided in Chapter 9, Freshwater Environment Characterisation, and Chapter 12, Socioeconomic Environment Characterisation, of the Project EIS respectively (WGJV, 2018).



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WAFI-GOLPU JOINT VENTURE

Wafi-Golpu Project

Sub-catchments in the Lower Watut River catchment

Figure No: **3.1**

3.1.7. Groundwater

Groundwater systems in the Project Area comprise alluvial aquifers associated with the expansive floodplains of the Lower Watut River and Markham River, and shallow and deep aquifers associated with faults and fracture zones in the weathered and partially weathered bedrock of the Mine Area. Both systems are recharged through ground infiltration following rainfall, with the rivers hydraulically connected to the alluvial aquifers. The water table in the alluvial plains is between 0.28mbgl and 2.54mbgl.

Faults through Mt Golpu provide preferential pathways for groundwater flow through the strata including the orebody. Groundwater flow through the strata decreases with depth. These aquifers discharge through springs and into watercourses, as baseflow, with artesian conditions on the eastern flanks of Mt Golpu. Groundwater quality is reflective of the low residence time and mineralisation of the host rock. Groundwater-fed springs supply drinking water to a number of villages in proximity to the Mine Area, with watercourses providing a secondary supply.

Further information on groundwater in the Project Area and its existing use is provided in Chapter 8, Physical and Biological Environment Characterisation, and Chapter 12, Socioeconomic Environment Characterisation, of the Project EIS respectively (WGJV, 2018).

3.1.8. Land Use

Much of Morobe Province (approximately 65%), including the general Project locality, is forested. Urban development in Morobe accounts for less than 5% of land use. About 10% of the land area is grassland. There has been an increase in agricultural land use in the province (to around 25% of the land area, mainly for subsistence agriculture) associated with a marked increase in population (in the order of 4% per year) between 1975 and 2000 (Ningal et al., 2008).

Elsewhere in PNG, there have been well documented increases in local populations (in-migration) associated with resource development projects (e.g., Kemp et al., 2012) and it is reasonable to expect that implementation of the Project will similarly induce at least local-scale changes in population along new roads with associated changes in land use. Post-mining land uses in the immediate Project Area will be subject to negotiation and agreement with customary landowners and other relevant stakeholders.

Further information on existing land use in the Project Area is provided in Chapter 12, Socioeconomic Environment Characterisation, of the Project EIS (WGJV, 2018).

3.2. Socioeconomic Setting

This section summarises the socioeconomic setting for the Project. Further information is provided in Chapter 12, Socioeconomic Environment Characterisation, of the Project EIS (WGJV, 2018). Consistent with Chapter 12 of the Project EIS, the socioeconomic setting is divided into the following four study areas:

- Study Area 1: Mine Area, surrounds and access corridors
- Study Area 2: Infrastructure Corridor from Zifasing to Lae
- Study Area 3: Lae
- Study Area 4: Wagang and Yanga villages

A brief summary of the Morobe Province socioeconomic setting is provided to contextualise the four study areas.

3.2.1. Morobe Province

At the 2011 Census, Morobe Province was PNG's largest province, accounting for 9.3% (646,876) of PNG's population with a low population density (20 persons per square kilometre) (NSO, 2011). The three main urban centres in Morobe Province and the respective population of each centre are: Lae (148,334), Wau/Bulolo Urban (10,598) and Finschafen Urban (2,890) (NSO, 2011). Between 2000 and 2011, Morobe Province's annual population growth rate of 2.1% was relatively low compared to that of PNG (3.1%) (NSO, 2011).

The administrative and commercial centre of Morobe Province is the city of Lae. Significant population growth and settlement is occurring westwards from Lae following the Highlands Highway toward Nadzab, in an area currently the subject of a major urban development plan supported by the Japanese International Cooperation Agency (JICA, 2017).

The economy of Morobe Province is based on agricultural production (cattle, chickens, copra, cocoa, sugar and coffee) and processing (chicken processing, tuna canning) as well as mining and service industries. Lae is the major commercial centre servicing the Highlands and Ramu areas, and has experienced high levels of growth over the last 10 years. Due to its port and position on the Highlands and Bulolo Highways, Lae is considered to be PNG's leading distribution and logistical hub.

3.2.2. Socioeconomic Study Area 1: Mine Area, Surrounds and Access Corridors

This study area comprises 29 villages, located near the Mine Area, along the Demakwa Access Road, and along the proposed Mine Access Road and Northern Access Road. Villages within this study area (and only this study area) are further divided into two tiers: Tier 1 (those in closest proximity to the Mine Area); and Tier 2 (more distant from the Mine Area, located on the west side of the Lower Watut River or along proposed or existing access routes).

Tier 1 comprises 16 villages, which have been categorised as Tier 1 due to their proximity to and ownership of land on which mining and associated activities would be conducted. The combined population of Tier 1 villages was estimated to be 3,869 persons in 2017. Tier 1 villages and corresponding cultural groups are:

- Hengambu cultural group: Hekeng, Fly Camp, Bavaga and Gingen
- Yanta cultural group: Venembele, Nambonga, Pekumbe, Pokwaluma, Pokwana and Zilani
- Babuaf cultural group: Madzim, Wori, Wongkins, Kapunung, Papas and Ziriruk

Tier 2 villages are those situated along or near the Demakwa Access Road and proposed Mine Access Road and Northern Access Road, and those located on the west side of the Lower Watut River (villages located on the east side of the Lower Watut River are within Tier 1). Tier 2 villages include owners of land through which access routes pass, as well as villages in proximity to the Lower Watut River whose residents have the ability to utilise these access routes. Tier 2 villages had an estimated population of 6,066 persons in 2017.

Thirteen villages were identified as Tier 2 villages within Study Area 1:

- Villages along/near the Northern Access Road: Kokok, Chiatz, Ngarubuaring, Chaunon and Mafanazo
- Villages along/near the Demakwa Access Road: Timini, Dengea and Zimake
- Villages along/near the Lower Watut River: Uruf, Wampan, Bencheng, Maralina and Goraris

3.2.2.1. Economy

In recent years, the exploration phase of the Project has provided the main source of wage employment for villages in this study area. This declined over 2014-2015 as the Project Pre-Feasibility Study phase was concluded.

Beyond opportunities provided by the Project, village surveys over the period 2014-15 highlight the significance of alluvial mining, cash crops and business activities such as trade stores and stalls. Sales of livestock and river and forest products, and the receipt of wages, compensation payments, gifts and remittances, also contribute to household income.

Survey results also indicate that income levels and the main sources of income vary substantially between villages.

Across Tier 1 villages, alluvial mining provided a source of income for 24% of households in the fortnight preceding the time the 2014 survey was undertaken, and for 55% of households in the preceding year. Alluvial mining is more frequently undertaken in the villages along the Wafi River, where families often construct a diversion channel in a river or stream (creating a stretch of water that is lower or slower moving than the main channel) to dive for nuggets and then pan and use a sluice.

While not as frequent as along the Wafi River, alluvial mining also occurs in the Lower Watut River as a secondary source of cash income to cocoa, which is the main cash crop in the Lower Watut area. Households on the Lower Watut River commonly use a sluice box to extract gold from areas of river sand or from sand beds on the river plains a metre or more below the surface.

Cocoa is the main cash crop in and around the Mine Area, supplemented by peanuts and watermelon. Occasionally, surplus staple foods, such as bananas and taro, are also sold.

3.2.2.2. Education

According to socioeconomic surveys conducted within this study area in 2014 and 2015, within Tier 1 villages:

- 46% of males and 32% of females aged 10 years and above had completed Grade 6
- 15% of males and 6% of females aged 10 years and above had completed Grade 10
- 4% of persons aged 10 years and older had completed a degree or course at a vocational school, a technical college or a university
- 17% of males and 32% of females aged 10 years and above had no formal education

Due to the distance required to travel to elementary and primary schools, residents of Fly Camp, Hekeng, Venembele, Nambonga, Pekumbe, Pokwaluma, Zilani and Pokwana reported (in the 2014–2015 surveys) that they were unable to access formal education facilities. The WGJV had, in 2013, constructed elementary schools and provided basic materials (desks, chairs, blackboards and teaching materials) in Hekeng, Venembele, Pekumbe, Kapunung and Madzim. At the time of the 2014–2015 surveys, these schools were awaiting allocation of teaching staff; they are now operational.

There are no secondary schools in the area and access requires up to three days' travel. The majority of secondary school students, therefore, attend boarding schools or live with family members located in proximity to schools.

3.2.2.3. Health

The average age of residents for Tier 1 villages was estimated to be 18 years in 2015, which is slightly lower than the average age of 19.7 years for the population of PNG. The proportion of the population aged over 65 years (1.4%) was lower than the proportion of the population of PNG aged over 65 years (2.1%). This suggests a lower average life expectancy than the population of PNG (62 years for males and 65 years for females). Tier 2 villages recorded an average age (19 years) and proportion of the population aged over 65 years (2.1%) which was comparable with that of the population of PNG.

The most prevalent causes of death reported in earlier 2012 socioeconomic surveys included malaria (21.2%) and general illness (14.9%). Death from childbirth and deaths attributed to sorcery were both reported to be 9.6%, which was higher than death from tuberculosis (6.4%), accidents (6.4%) and cancer (6.4%).

The 2012 household survey found the most prevalent illnesses were colds and flu, followed by malaria and fever (Coffey, 2013). The 2012 Public Health and Biomedical Survey found acute respiratory infections to be the most frequent acute illness among those surveyed (Abt JTA, 2012).

3.2.2.4. Community

Gardens, typically located within 3km of villages, are the most important source of household food. The most commonly grown produce includes bananas (97%), greens/kumu (94%), kau kau (sweet potato) (92%), taro (92%) and sugar cane (85%).

Based on socioeconomic surveys conducted in 2012, sharing of goods was reported as being common in Tier 1 villages, especially amongst neighbouring households and those of close kin. Goods may be distributed when there is a harvest or surplus fish catch. Reciprocation comes in the form of returning goods in kind if they are available immediately. Otherwise, it is reciprocated in cash or kind at a later date when the receiving household obtains surplus goods. Each household makes an extra effort either in gardening, hunting or, for those employed, bringing home extra cash to maintain the cycle of giving and paying off what is owed.

3.2.3. Socioeconomic Study Area 2: Infrastructure Corridor from Zifasing to Lae

The Infrastructure Corridor from Zifasing to Lae will traverse through or near Zifasing, Ganef, Gabsongkeg, Nasuapum, Munum and Yalu villages, associated hamlets and settlements, and a number of industrial and commercial premises.

In studies conducted in 2017, each of these villages reported a mostly subsistence lifestyle, sourcing food by gardening, hunting and fishing. Two markets are located at Zifasing, where with a range of crops are sold, including garden produce (e.g., bananas, root crops and greens) and cash crops (primarily cocoa but also watermelon).

Drinking water for villages in this area is principally sourced from either springs and wells, or nearby creeks (which often act as auxiliary sources of water). In Yalu, piped water (sourced from the Yalu River) was reported to supply water for drinking, washing and bathing.

The estimated populations in 2017 for villages in these areas ranged from approximately 317 persons at Ganef village, up to 2,608 persons in Zifasing (which is over double the population of any village in or around the Mine Area, i.e., any Tier 1 or 2 village).

From Yalu village to the outskirts of Lae, numerous businesses and industrial facilities, and at least two schools, are located adjacent to the Highlands Highway. Further to the south, the Infrastructure Corridor will traverse land used for commercial agriculture. The proposed Infrastructure Corridor will run past Wanaru Farm (premises used by Niugini Tablebirds to raise chickens), premises occupied by Mainland Holdings (which operates a crocodile farm), and premises used by PNG Steel Limited as a laydown area.

3.2.4. Socioeconomic Study Area 3: Lae

Lae had recorded population of 148,934 persons in the 2011 Census (NSO, 2011), making it PNG's second largest city. It is the national industrial centre, hosting a range of industries including meat processing, beverage manufacturing, flour milling, cement processing and fish canning. Other industries include transportation, commercial, wholesale and retailing, oil and petrol distribution and cartage. The city is well connected to the rest of the country via the Highlands Highway, a domestic airport and the country's largest port.

Participation in the formal economy in Lae has provided its residents generally higher incomes, employment rates and education levels compared to most other parts of PNG and Morobe Province (JICA, 2017). Healthcare is more readily available in Lae than the other socioeconomic baseline study areas, with two hospitals, seven clinics and four aid posts.

The Port of Lae, where the Port Facilities Area will be established, is PNG's largest and busiest port. It handles about half of the throughput of the 22 declared ports of PNG, and more than 60% of registered international and coastal trade, generating more than 50% of PNG Ports Corporation revenue (PNG Department of Transport and Infrastructure, 2013). The Port of Lae is located in a heavily industrialised area, characterised by numerous industrial warehouses and port facilities.

The Infrastructure Corridor will pass along the western perimeter (Markham River side) of 3 Mile and Bugandi (a suburb of Lae), both predominantly residential areas with settlement housing, settler gardens and roadside stalls, before arriving at the Port of Lae, where the concentrate and fuel pipelines will terminate.

The terrestrial tailings pipeline will continue north and east from the industrialised area at the Port of Lae, traversing the city centre of Lae en route to the village of Wagang. This section of the proposed corridor will be wholly constructed beneath public roads, adjacent to which numerous industrial facilities, businesses, health facilities and community premises are located. The Infrastructure Corridor will pass within 150m of the Australian New Guinea Administrative Unit (ANGAU) Hospital, which is the second largest hospital in PNG.

3.2.5. Socioeconomic Study Area 4: Wagang and Yanga Villages

Wagang village is a coastal village located approximately 3km east of Lae and approximately 1.6km from the proposed Outfall Area, with an estimated population of 626 persons in 2017. Yanga village, to the north of Wagang, is an inland village with an estimated population of 620 persons in 2017.

Being peri-urban communities, Wagang and Yanga villages have greater opportunity to access employment compared to villages in other study areas. Residents in both villages engage in and rely on subsistence activities, such as gardening, fishing, gathering and hunting. Household surveys in 2017 estimated that 40% of food consumed in Wagang is harvested from gardens. Surplus produce (e.g., garden crops or fish) is sold for income. Additionally, on weekends the residents of Wagang sold food, drinks and other goods to visitors to Wagang beach, which provides an additional source of income.

For both villages, the land available for subsistence activities is bounded by the Busu River, the city of Lae and the shoreline, resulting in limited capacity to accommodate population growth.

4. STAKEHOLDER ENGAGEMENT

Stakeholder consultation regarding closure is required that considers the interests and concerns of stakeholders, as well as sustainable outcomes, during the closure planning process. Stakeholder identification and stakeholder consultation proposed for closure are discussed in the following section.

4.1. Stakeholder Identification

The Wafi-Golpu Joint Venture recognises that effective consultation and engagement is essential for successful closure. Stakeholder engagement is guided by the Stakeholder Engagement and Management Plan (WGJV, 2016), which will be updated throughout the life of the Project. The Stakeholder Engagement and Management Plan is based on the requirements of the WGJV Stakeholder Consultation and Involvement Standard (COM02) and is informed by the Community Baseline Studies Standard (COM06). The key stakeholder groups, and specific stakeholders within the groups, are listed in Table 4.1 and described further in the Stakeholder Engagement and Management Plan (WGJV, 2016).

Table 4.1: Key Project stakeholder groups

Key Project Stakeholder Groups	
Community and Landholders	
• Babuaf villages including: Madzim, Kapunung, Papas, Wongkins, Wori and Ziriruk • Hengambu villages including: Bavaga, Gingen, Hekeng and Fly Camp • Yanta villages including: Nambonga, Pekumbe, Pokwaluma, Pokwana, Venembele and Zilani • Villages located to the southwest of the Mine Area on the western side of the Lower Watut River, including: Bencheng, Uruf, Maralina, Goraris and Wampan • Vulnerable groups (women and youth)	• Villages and hamlets along or near the Infrastructure Corridor from the Mine Area to Wagang including: Busanim, Chaunong, Chiatz, Gabsongkeg, Kamkumung, Kokok, Mafanazo, Munum, Nasuapum, Ngarubuaring, Yanga, Yalu, and Zifasing • Villages located near the Demakwa Access Road and Bulolo Highway including: Dengea, Timini and Zimake • Lae communities and groups • Coastal communities (Labu and Wagang)
Landowner Associations	
• Babuaf Landowner Association • Hengambu Landowner Association	• Yanta Development Association • Wafi-Golpu Community Consultative Committee
National Government	
• Chief Inspector of Mining • Conservation and Environment Protection Authority (CEPA) • Department of Finance • Department of Mineral Policy and Geohazard Management • Department of National Planning and Monitoring • Department of Justice (Office of the State Solicitor) • Department of Lands and Physical Planning • Department of Provincial and Local Government Affairs • Department of Trade, Commerce and Industry • Department of Treasury • Department of Works	• Environment Council • Mineral Resources Authority (MRA) • Minister for Environment, Conservation and Climate Change • Minister for Mining • National Council of Women • National Department of Health • National Executive Council • National Fisheries Authority (NFA) • National Research Institute • Kumul Consolidated Holdings Limited • Kumul Mineral Holdings Limited • PNG National Museum and Art Gallery (NMAG) • PNG Power Limited • PNG Ports Limited
Morobe Provincial Government	
• Governor • Provincial Executive Council • Member of Parliament for Huon Gulf	• Member of Parliament for Bulolo • Member of Parliament for Lae

<table>
<tr><th colspan="2">Key Project Stakeholder Groups</th></tr>
<tr><td colspan="2">Morobe Provincial Administration</td></tr>
<tr><td>Advisors to the District Development authorities
Bululo, Huon Gulf and Lae District Development Authorities and their Chief Executive Officers
Bulolo and Morobe Police
Provincial Administrator</td><td>Provincial Council of Women
Provincial Mining, Natural Resources and Environment Office
Provincial Programme Advisors (Health, Education, Agriculture, Fisheries, Planning, Mining, Commerce, Provincial Affairs, Village Courts)</td></tr>
<tr><td colspan="2">Local Level Government (LLG)</td></tr>
<tr><td>Ahi LLG President and Councillors
Mumeng Rural LLG President and Councillors</td><td>Lae Urban LLG Lord Mayor, President and Councillors
Wampar Rural LLG President and Councillors</td></tr>
<tr><td colspan="2">Training and Education Institutions</td></tr>
<tr><td>PNG University of Technology
National Polytechnic Institute (Lae Tech)</td><td>University of Papua New Guinea</td></tr>
<tr><td colspan="2">Industry</td></tr>
<tr><td>Chamber of Mines and Petroleum
Mining companies outside of PNG
Lae fish canneries (existing and proposed)</td><td>PNG Chamber of Commerce and Industry
Lae Chamber of Commerce and Industry</td></tr>
<tr><td colspan="2">Project and Operations</td></tr>
<tr><td>Project employees and contractors
Newcrest Mining Limited and Harmony Gold Mining Company Limited employees and contractors</td><td>Suppliers and supply chain partners (e.g., port authorities, transport companies)
Participants' investors and financiers</td></tr>
<tr><td colspan="2">Other</td></tr>
<tr><td>Lae Yacht Club
Lae Game Fishing Club
Media</td><td>Local churches (Lutheran church and other denominations)
Non-government organisations (NGOs)
Australian High Commission</td></tr>
</table>

4.2. Stakeholder Consultation for Closure

The closure consultation process aims to keep stakeholders engaged by developing and agreeing on final closure objectives and criteria, and on a process for the handover and relinquishment of the SML area following closure. This is guided by the following specific objectives:

- Stakeholders are included in the closure process, their interests are considered, and they participate meaningfully in the process
- Closure outcomes are achievable and sustainable
- Requirements of the government are met
- Potential socioeconomic opportunities following mine closure are identified, investigated and addressed as appropriate

The closure consultation process will be part of WGJV's broader stakeholder consultation processes and will build on previous consultations and on relationships established during the studies and permitting stages of the Project. Consultation mechanisms will be further expanded and refined during the Project's operation phase.

A key measure proposed to enable meaningful stakeholder input would be the formation of a closure reference group. This group would be integrated into an overall stakeholder engagement strategy and would provide a useful forum for discussion and communication on closure issues. While the closure planning process at this stage is conceptual, the invited members of the closure reference group could include representatives from:

- The government (both national and provincial)
- Representatives of the landowner groups
- Broader community representation (where appropriate)
- The WGJV Participants
- Independent technical specialists on an ad hoc basis

It is expected that the closure reference group would be formed during operations with meetings becoming increasingly frequent within the last five years.

In addition to the closure reference group, the WGJV would engage key stakeholders via workshops, focus groups and through ongoing consultation activities to inform development of the closure strategy.

The stakeholders to be involved in closure planning, and the content and nature of discussions with stakeholders, will be refined by the closure reference group as the Project approaches the closure phase.

5. CLOSURE STRATEGY

5.1. Approach

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

- A closure framework (including closure objectives that will lead to the development of closure criteria during the life of the mine)
- Plans for implementing decommissioning, rehabilitation, and ongoing maintenance
- A strategy for unforeseen circumstances such as unplanned mine closure

As part of the WGJV's conceptual closure framework to support the EIS, closure objectives have been defined for each domain. Through the life of the Project, criteria will be defined for each Project closure domain as the closure plan evolves as a 'live' document (see Section 6).

The closure framework will consist of:

- **Objectives.** A clear set of statements relating to environmental and social aspects of mine closure that describe the intent of the mine closure program.
- **Criteria.** Specific elements that can be measured or certified to have occurred, and demonstrate that objectives have been achieved. Each objective may have more than one criterion, and a criterion may apply to more than one objective.

5.2. Risk Assessment

A preliminary assessment of environmental closure and rehabilitation risks has identified categories of inherently high risk as follows:

- The need for ongoing treatment of poor water quality discharges from the subsidence zone lake for an unknown period in the post-closure period.
- Reduction in groundwater and/or surface water quality due to acid generation and metals leaching (various sources, including groundwater seepage through subsidence zone, discharge of groundwater from mine portal or other openings, contact of surface

water with acid-generating materials in borrow areas, or leachate from the waste rock dumps).
- Public safety hazards associated with mine openings (portals, ventilation shaft) and the subsidence zone.

The proposed implementation measures described in Section 6 primarily focus on these inherently high risk closure elements. Lower risk rehabilitation and closure events have also been identified and these events include:

- Poor revegetation outcomes resulting from ineffective topsoil management, storage and placement practices
- Ecosystem impacts associated with ineffective control of weeds
- Release of fugitive sediment from disturbed land surface, engineered landforms or materials stockpiles

A preliminary assessment of socioeconomic closure risks has identified the following areas of potential concern:

- Adequacy of community engagement to understand expectations for closure
- Social tensions following the loss of direct economic benefits and employment
- Conflict or competition for resources as a result of in-migration
- Inability to diversify the local economy results in continued dependence on mine-derived employment and income and the inability to re-deploy the locally-engaged workforce
- Loss of population from Tier 1 and Tier 2 villages due to potential exodus of villagers seeking alternative employment

Proposed key actions to help reduce the potential impacts of mine closure risks in each closure domain are described in Section 6.

5.3. Proposed Closure Objectives

The WGJV has proposed a set of closure objectives to limit key risks to decommissioning, rehabilitation and closure. These are presented in Table 5.1.

Table 5.1: Proposed Closure Objectives

Aspect	Proposed Objective
Planning	
	Provide a systematic process for the planning, validation and reporting of decommissioning and rehabilitation activities.
	Comply with legislative requirements and approval conditions related to decommissioning, closure or rehabilitation.
	Include stakeholders in the closure planning process and consider their interests.
	Fulfil closure-related commitments that may be developed through ongoing consultation with stakeholders.
	Manage any need for long-term surveillance, monitoring, treatment and/or maintenance in the post-closure period.
	Sustainable long-term management, that may include transfer of assets to a third party following appropriate assessment of ongoing maintenance requirements.
	Achieve relinquishment of leases following implementation of post-closure decommissioning, remediation and rehabilitation measures.

Aspect	Proposed Objective
Physical	
	Provide for safe and stable post-closure landforms, including geotechnical stability and geochemical reactivity, to manage public health and safety risks and potential risks to the environment.
	Meet the requirements (and criteria) for the agreed land use of each domain.
	Provide for resilient and self-sustaining ecosystems and landscape function in areas that are rehabilitated.
	Minimise adverse post-closure effects on the receiving environment.
Socioeconomic	
	Work with government and local communities in the transition to post-closure livelihoods if required (noting that this process should commence during the operational phase of the Project).
	Any remaining Project infrastructure (not taken over by the third parties) or landforms does not pose undue risk to community health and safety.

Potential management actions to achieve the proposed closure objectives and targets are described in Section 6. Closure criteria will be developed in consultation with the government and stakeholders including relevant communities during the operational stage of the mine as the closure plan is regularly updated and progressed beyond a conceptual stage.

6. IMPLEMENTATION

6.1. Overview and Timetable for Closure

The Project is expected to have a production life of 28 years (not including the construction and post-closure phases or any potential future extension or expansion of the mine).

Under the *Mining Act 1992*, the holder of a tenement may apply at any time to surrender the tenement in whole or in part, provided that the Registrar shall satisfy himself that the holder has complied with any conditions of the special mining lease that relate to the cessation of mining operations, restoration of the land and surrender (Sections 137 and 139).

It is anticipated that the closure process will comprise the following steps:

- Conduct progressive rehabilitation as disturbed land becomes available (e.g., worked out borrow pits, former drilling pads, and the waste rock dumps)
- Refinement of closure risks, objectives and criteria based on results of further investigations (including those outlined in Section 6.14) and stakeholder engagement
- Establishment of a closure reference group
- Agreement on a formal review and close out processes for rehabilitated areas, and mechanisms for transfer of control
- Regular briefings of the closure reference group providing updates on closure progress
- Preparation and submission of the Detailed Closure and Rehabilitation Plan
- Development of decommissioning, transition and implementation management plans, and landform engineering designs
- Final site remediation and rehabilitation, and closure monitoring and maintenance
- Reviews of closure progress, early close out of areas meeting closure criteria
- Final review of closure progress, agreement that site meets closure criteria

- Formal lease relinquishment

A detailed closure schedule for implementation will be developed during the operational stage of the mine as the closure planning progresses.

6.2. Decommissioning

In the lead up to closure, re-use and recycling opportunities for fixed and mobile plant and infrastructure will be considered. This could include the removal of selected equipment for use by a third party, or leaving some infrastructure *in situ* for alternative uses or community purposes. Where no feasible or practicable alternatives are identified, it is proposed that the Project components will be decommissioned.

Decommissioning will commence upon the cessation of mining activities and final processing of ore which will include the processing of all remaining stockpiled ore so that all remaining PAF material is encapsulated within the waste rock dumps. The declines and ventilation shaft will be appropriately sealed, and infrastructure, facilities, equipment and services (unless otherwise agreed with stakeholders) removed. At the end of its useful life, the Watut Process Plant will be decommissioned, dismantled and sold, buried or removed, as appropriate.

Other decommissioning activities are likely to include:

- Removing salvageable materials (e.g., steel, tanks, pipework, metal beams and sheeting) from site and selling these as scrap for recycling
- Removing and disposing of non-salvageable, non-contaminated materials in designated landfill/s or void/s; materials may include concrete foundations (if not buried *in situ*), miscellaneous building materials, tyres and similar
- Flushing, depressurising or emptying (or other decommissioning) sub-surface services (e.g., compressed air, mine dewatering or potable water pipelines) which will not result in adverse environmental impacts if left in place

6.3. Post-closure Land Use

The realisation of land rehabilitation and closure objectives will require different approaches, depending upon the intended post-mining land use. Land uses will be dictated by a range of factors, including:

- Legislative and regulatory requirements
- Government preferences, including at provincial and district level
- Local landowner preferences
- Land access (including both physical access and land tenure considerations)
- Land capability and physical constraints
- Economic factors and cost
- Pre-Project land uses

The regulatory and policy settings in PNG, especially the Mine Closure Policy and Guidelines (2005), place a strong emphasis on enduring social and economic benefits extending into the post-mining period. Social and economic benefits:

- Can arise from the transfer of infrastructure or assets from the mining company to stakeholders who have the technical and financial capacity to maintain them in the long term
- May result from productive use of land formerly used for mining

- Derive from people (including previous employees) who have gained marketable skills that are being used in other sectors
- Flow from the on-going upkeep and use of public infrastructure (such as health facilities and schools) previously supported by the mining company
- May accrue through the investment and on-going stewardship of compensation payments during the operational life of the mine

Part III, items (vi) through (viii) of the PNG Mine Closure Policy and Guidelines (2005) explicitly anticipates the transfer of some assets and infrastructure to "relevant stakeholders" at mine closure, by stating:

- Proper provision shall be made to have all assets valued prior to transfer to relevant stakeholders.
- Proper provision shall be made for the transfer of infrastructure and facilities to relevant stakeholders.
- Adequate provisions shall be made to ensure that any non-transferable assets and equipment shall be properly tendered and sold domestically or internationally or safely decommissioned and disposal thereof.

The WGJV intends to adopt a consultative and risk-based approach to defining post-closure land uses and arrangements for the disposal of assets. The closure approach will have regard to regulatory requirements, community preferences and WGJV perspectives. The default position will be that all assets and infrastructure associated with the Project will be decommissioned and/or removed at closure; however, this will be subject to negotiation with landowners, government and other stakeholders.

6.4. Progressive Rehabilitation

The WGJV proposes undertaking progressive rehabilitation where possible. As many of the Project domains (notably the underground mine) are not readily available for substantial progressive rehabilitation during the operations phase of the mine, most rehabilitation will occur once production ceases and decommissioning begins. There will be some areas (worked out borrow pits, former drilling pads, temporary laydown areas and the waste rock dumps) that can be progressively rehabilitated.

Progressive rehabilitation may involve some or all of the following:

- Reconstructing landforms to original or stable contours and drainage lines
- Reducing surface exposure to minimise the potential for erosion and fugitive sediment mobilisation
- Scarifying or ripping landform surfaces along the contours to alleviate compaction and allow for direct seeding and natural regeneration
- Applying brush matting, mulching or compost to assist with moisture retention
- Using native seed mixes in direct seeding that reflect pre-disturbance vegetation composition

Revegetation typically involves a two-step process, initially focusing on establishing stabilising plants before progressing to a mature, self-sustaining ecosystem of locally endemic species. Trials will be undertaken during operations to identify suitable native species for revegetation. Trials may use a range of species such as nitrogen fixing tree species, shrubs and ground creepers to readily establish and introduce nitrogen into the soil, along with dropping leaf litter that decomposes. Trials will also investigate the success of different revegetation methods such as hydroseeding, direct planting and natural regeneration. The outcomes of rehabilitation in these trial areas will be monitored and used to review the effectiveness of rehabilitation practices, which will be modified if required.

Topsoil salvaged during land clearing could be used to cover disturbed areas and to serve as a growth medium for the re-establishment of vegetation; however, stockpiling of soils for extended periods can have adverse impacts on microbiological activity in the stored soils and, therefore, compromise the re-establishment of vegetation at mine closure. This, in combination with the long mine life, high rainfall environment and steep terrain, means that topsoil stockpiles are unlikely to be used in the traditional way. Furthermore, the area required to create temporary stockpiles would increase the footprint of the Project.

In some instances where topsoil reuse is available for rehabilitation, methods of reusing topsoils will include direct topsoil return. This involves the stripping of topsoil and immediate respreading on disturbed areas.

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

Rehabilitation activities, both during operations and at closure, will be the subject of a detailed Closure and Rehabilitation Plan.

In the following sections, closure domains are described, domain-specific closure objectives and issues are discussed, and conceptual closure actions are then outlined.

6.5. Domain 1 – Mine Workings and Openings

6.5.1. Description

6.5.1.1. Declines

The twin Watut Declines and the Nambonga Decline will provide access to the underground block cave mining operations from the Watut portal terrace and the Nambonga portal (see Figure 1.2).

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.

The Nambonga Decline will provide access from the Nambonga Creek crossing of the Wafi Access Road. It will be approximately 6.8m high and 5.6m wide for the first 300m and thereafter reducing 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.

During operations, the declines will be supported by refrigeration and ventilation systems and a dewatering system to remove groundwater entering the declines. During mining, the 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.

6.5.1.2. Ventilation Shaft

A ventilation shaft will service the additional ventilation demands of the operation of the mine as the underground workings develop. 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).

6.5.1.3. Block Caves

The proposed mining method is block caving, a technique using the controlled collapse of a near-vertical orebody as a means of breaking and extracting the ore. Block caving uses three levels for each block cave (undercut, apex and production/extraction) as follows:

- '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 achieve correct and complete breakage 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.

Block caving of the orebody is proposed to utilise three extraction levels. The first block cave, BC 44, will be situated at 4,400 metres reduced level (mRL) and the second block cave, BC 42, will be situated at 4,200mRL. These two block caves are expected to be mined for eight and 13 years respectively during the first 15 years of mine life. The third block cave, BC 40, to be situated at 4,000mRL, is expected to be mined for 19 years. Overall the mine production life will be 28 years with design mine production rate of 16.84Mtpa; mining of the block caves will overlap for several years and hence, the individual 'lives' of the block caves are not additive.

During caving operations, ore from the block cave draw points 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 portal terrace will continue overland to deliver crushed ore to a coarse ore stockpile adjacent to the Watut Process Plant.

6.5.2. Closure Objectives

The closure objectives for management of the mine workings and openings are to:

- Make all mine workings and openings safe and secure and, to the maximum extent practicable, to prevent public access
- Minimise the potential for AMD generation or discharge to the surrounding environment
- Manage the discharge of water from the block caves so that the quality meets regulatory criteria

6.5.3. Closure Issues

The majority of the declines, ventilation shaft and block caves are expected to be within PAF rock types with the potential to produce AMD. Consequently, oxidation products will be present at the end of mining, and if oxygen supply and sulphide oxidation continued, these structures could affect surface and groundwater quality in the long-term.

At cessation of mining, active dewatering of the mine will cease and the mine workings will be progressively inundated (which will be accelerated by pumping water into the workings) as groundwater levels rise. Without this intervention, the decline portals would become perpetual discharge points and diminish the capacity to fully flood the underground workings.

The declines and ventilation shaft will have reducing oxygen levels and are likely to collapse in the long term and, therefore, pose a risk if entered. Accordingly, their entrances will be secured.

Piteau Associates (2018) prepared numerical models to predict the dynamics of the groundwater and surface water system in the block caves and subsidence zone following closure of the mine. This assessment compared three management scenarios:

- No active intervention is applied to moderate rates of inundation of the cave zone.
- Accelerated flooding of the cave zone through pumping of water from a fluvial source at a nominal rate of 500L/s until such time as inundation reaches the base of the subsidence zone (at around 250mASL).
- Accelerated flooding of the cave zone (as above) with concurrent addition of a hydrated lime ($Ca(OH)_2$) slurry, administered to maintain a nominal pH of 7. This was estimated to be around 3g/L (or 189,216t over the 4-year period), assuming 100% lime purity and complete lime-consumption in the neutralization of acidity.

An important assumption in relation to accelerated flooding is that it would occur at the draw point elevation, rather than at the upper elevation of the cave (as would occur in the event of infiltration through the subsidence zone). This has benefits in terms of water quality during the initial period of water accumulation as flushing of the rock column occurs only by progressive inundation from the base-up, rather than by diffuse seepage from the 250mASL elevation downward through the entire rock column.

Findings from this modelling concluded that water quality will to a substantial extent be dependent on the time-frame over which complete flooding occurs, and hence the period over which exposed sulphide in the cave walls will continue to generate acidity, sulphate and metals through oxidation (Piteau Associates, 2018).

Under conditions of passive flooding of the block cave, complete inundation to the base of the overlying subsidence zone is likely to occur over a time period of around 45 to 55 years. Under this inundation scenario, the quality of water in the block cave zone will be acutely acidic with corresponding high concentrations of metals and sulphate (Piteau Associates, 2018).

Under a scenario in which flooding of the block cave is accelerated through pumping from a fluvial source, complete inundation to the base of the subsidence zone would occur in a period of around 4 years. Accelerated flooding, in isolation, is predicted to reduce but not eliminate the risks of degradation of both re-activated spring water and of wider groundwater system plume development (Piteau Associates, 2018). Under this scenario while the period of time over which active oxidation of sulphides in the rock mass within the block cave is reduced, the contact water pH will still remain low.

The application of an accelerated flooding strategy, but with supplementation of the artificial recharge flow with hydrated lime is predicted to offer significant short term benefits to the water quality of the inundated cave zone, both in terms of pH and metals.

6.5.4. Proposed Closure Actions

The WGJV proposes the following conceptual closure actions:

- Install reinforced concrete plugs to block human access and seal off air flow to the ventilation shaft soon after closure to prevent convective oxygen supply to the sulphides within the subsidence zone. The plug will also direct surface drainage away from the shaft area.
- Install engineered hydraulic plugs / bulkheads in the decline portals to block human access and seal off air flow but also to prevent or minimise water discharge. The plugs

will need to withstand the substantial hydraulic head difference between the portal elevation and the ultimate height of the subsidence zone lake.

- Accelerate the flooding of the block caves and filling of the subsidence zone lake at a nominal rate of 500L/s. This would involve switching dewatering pumps to flooding pumps and recharging through an artificial recharge point at the base of the declines. The progressive inundation from the base of the declines upwards during the initial period of water accumulation, rather than by diffuse seepage downward through the rock column, will have a beneficial influence on water quality.
- Add hydrated lime (nominally 3g/L) to the flooding water (sourced from the Watut River) that will be discharged into the block cave to attain a pH end-point of nominally 7.0.

These proposed actions will be reviewed as detailed development of the closure plan progresses.

6.6. Domain 2 –Subsidence Zone

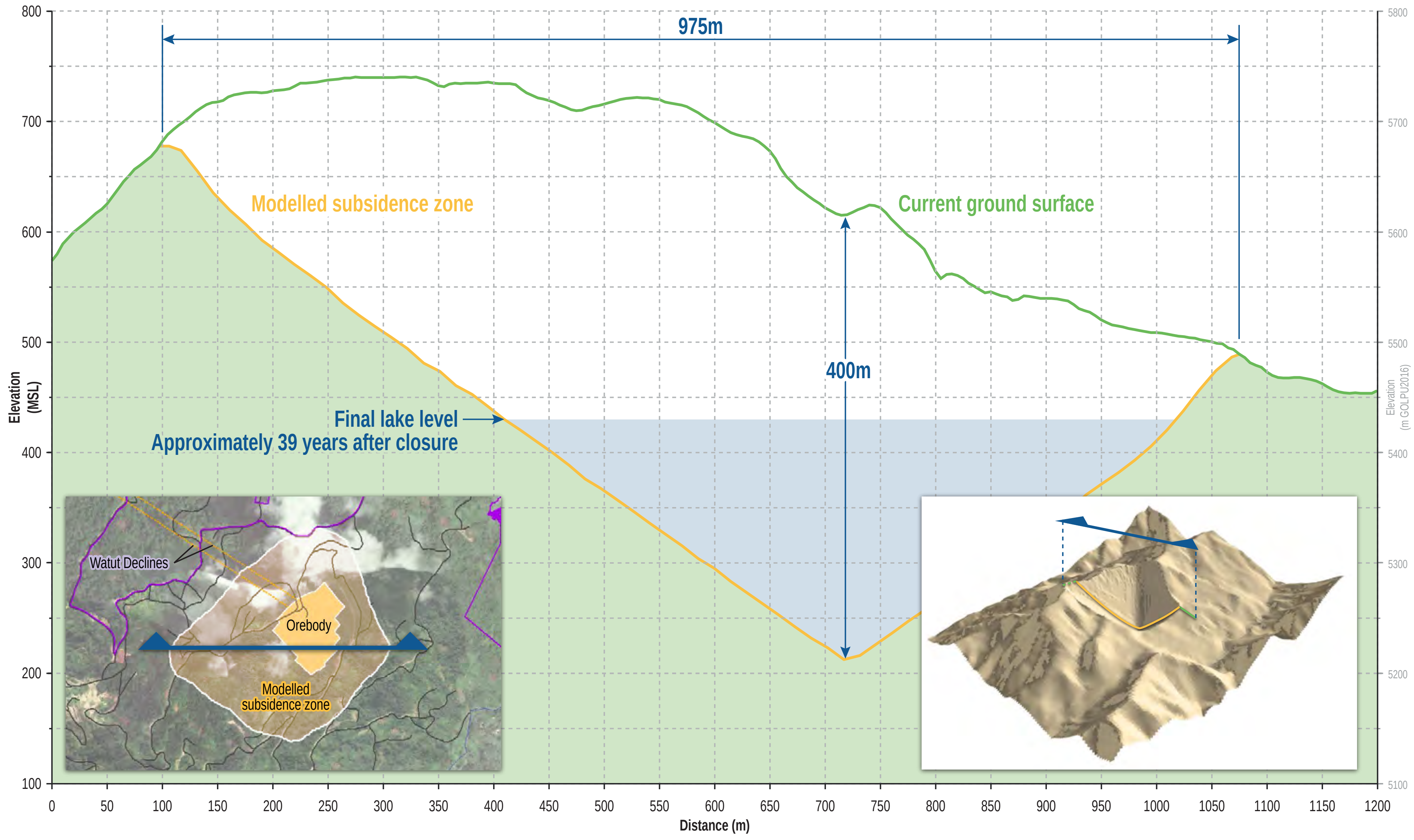
6.6.1. Description

Approximately 38 months after the start of block caving, a subsidence zone is expected to start to form on the ground surface above the orebody. This is due to the downward collapse of broken rock into the cave zone. This is known as the surface breakthrough.

By end of mining, the subsidence zone is predicted to be approximately 400m deep and 975m in diameter at its widest extent. Figure 6.1 shows the predicted maximum extent of the subsidence zone, as modelled for operation year 27, as well as the current topography of Mt Golpu.

It is expected that the rock underlying the subsidence zone will be highly fragmented with considerably greater porosity and permeability than the existing rock. The upper elevation of the subsidence zone lip is expected to lie at 450mASL, potentially creating a lake that is up to 200m deep.

At closure, mine dewatering pumps will be used to pump water from the Watut River to the base of underground workings. The groundwater level will progressively rise inundating the block cave after an estimated 4 years. Thereafter, groundwater inflow, direct precipitation and runoff from the subsidence zone walls will cause the lake level to rise to an estimated 450mASL when, after about 35 years, it is expected to start discharging at between 10 and 25 L/s to the natural environment at the lake spill point (topographic low point in the subsidence zone). Rising water levels in the subsidence zone will result in recovery of the cone of depression in the surrounding rock units. As a consequence, re-activation of some springs and the associated discharge of groundwater at the topographic surface may occur. Model projections suggest that this will occur by around 80 years post-closure. Steady state rates of spring discharge are predicted to be of the order of 7 L/s around the block-cave.



coffey
A TETRA TECH COMPANY

Date: 04.06.2018
Project: 754-ENAUABTF100520DD
File Name: 0520DD_10_Att6_F06.01_GRA

WAFI-GOLPU JOINT VENTURE

Wafi-Golpu Project

Modelled subsidence zone and final lake approximately 39 years after closure

Figure No: 6.1

INDD Reference: 0520DD_10_GRA029.indd_10

Under the closure management scenarios modelled, discharge from the subsidence zone to the natural drainage is not expected to occur until some 35 years after closure. There is, however, potential to accelerate this phenomenon if pumping from the Watut River were to continue beyond flooding of the block caves. This would allow inundation of exposed PAF material within the subsidence zone at a faster rate thereby reducing oxidation and acid formation.

There is currently uncertainty in relation to the discharge point(s) of the subsidence zone lake. Further work to refine the understanding of the groundwater system, the geometry of the subsidence zone and predictions of subsidence zone lake discharge will continue during construction and operation of the Project.

6.6.2. Closure Objectives

The closure objectives for management of the subsidence zone and subsidence zone lake are to:

- Minimise the potential for AMD generation in the subsidence zone post closure
- Limit the requirement for, and duration of water treatment post-closure
- Manage any discharge of water from the lake so that the water quality meets regulatory criteria
- Prevent, to the extent practicable, human access to the block cave subsidence zone

6.6.3. Closure Issues

6.6.3.1. Potential for AMD generation in the block cave subsidence zone

At the cessation of mining, groundwater will be well below its pre-mining level as a result of mine dewatering, and the subsidence zone will be a large void. The rock mass underlying the void and comprising the subsidence zone walls will be highly fragmented with substantially greater porosity and permeability than the existing *in situ* rock.

Most of the rock within the subsidence zone is expected to be argillic and advanced argillic rock types which are known to be predominantly PAF. Oxidation of the reactive sulphides within these rock types will occur in the presence of air and water and AMD is expected to occur. During operations, this acidic water will be treated if required before reuse or disposal to meet regulatory water use permit conditions at defined monitoring points. After closure, the rock within the subsidence zone will be progressively inundated by the rising water level and the quantity of exposed PAF material will gradually decrease until the subsidence zone lake is formed and starts to overflow. At that time (estimated to be about 35 years after closure) all PAF material below the lake surface will remain permanently underwater and oxidation will effectively cease. However, any exposed PAF material above the lake level within the subsidence zone or exposed in the walls will continue to oxidise and produce AMD until all of the available reactive sulphides are exhausted. The AMD generated within the subsidence zone above the lake level will affect the water quality within the subsidence zone lake and its discharge via springs and its spill point.

Prediction of the quality of water which will accumulate in, and ultimately discharge from, the subsidence zone lake is complex. Initial, simplistic, modelling simulations suggest that lake water chemistry will be similar to the block cave.

Assuming full mixing, the lake water quality is projected to improve progressively during the period of flooding of the lake in either passive (modelling scenario 1) or pumped (modelling scenario 2) situations as predicted by Piteau Associates (2018). By the time of initial discharge to the surface water drainage network, pH levels of around 5 are anticipated, with sulphate levels of 245mg/L (see Table 6.1). The predicted concentrations of Fe, Mn, and

Cu would exceed the PNG Environment (Water Quality Criteria) Regulation 2002 – Schedule 1 – Water Quality Criteria for Aquatic Life Protection.

With concurrent addition of a hydrated lime slurry to the force fill flows (scenario 3), the pH trend predicted for the period of lake development is effectively reversed, with a level of above pH6 likely during the early years of lake formation declining to around pH5.5 by the onset of discharge via the lake spill point. The concentrations of metals are predicted to be lower compared to the passive or pumped scenarios without lime addition (Piteau, 2018). However, the predicted concentrations of Mn and Fe would still exceed the PNG Environment (Water Quality Criteria) Regulation 2002 – Schedule 1 – Water Quality Criteria for Aquatic Life Protection (see Table 6.1). Concentrations of As, Cd, Cr, Cu and Zn are predicted to be below the same criteria.

Above the subsidence zone lake, the walls rise up to 200m vertically until the natural topography is reached. High walls extend to the west, north and northeast of the void lake. Any PAF materials that occur within these elevated walls will be exposed to oxidation and may generate AMD. Water quality modelling to date has not considered this potential source of acidic runoff into the subsidence zone lake; therefore, in this regard the modelling to date does not include the most conservative assumptions. However, prediction of the water quality in the subsidence zone lake is very complex and modelling to date does not include some factors that may be beneficial to final water quality. For example, predicted lake chemistries assume a fully mixed water column, where in reality the lake water is likely to be stratified. Also not modelled to date is the potential for adsorption of dissolved metals onto particulate matter. Tests by CSIRO on Watut River water has shown significant (up to 30%) metals attenuation is likely. Modelling of final pit lake water quality and engineering solutions will be progressively improved as actual data is accumulated during operations.

6.6.3.2. Discharge from the subsidence zone lake and springs

Post closure water modelling indicates that, once the equilibrium level is reached, at about 450mASL, discharge from the subsidence zone lake will occur at rates between 10 and 25L/s. With regards to the pathway and fate of groundwater discharge, Piteau (2018) concluded that "water conveyed in response to the head within the lake will pass through the groundwater system predominantly on the eastern side of Mt Golpu… ultimately discharging in one or more springs"; it also stated that "Spring SPR04 is located at a distance of only around 70 m from the projected limit of the subsidence zone and may prospectively form a major point of discharge." Steady state spring discharge rates are predicted to be of the order of 7 L/s around the block-cave.

Prediction of the quality of water that will accumulate in, and ultimately discharge from, the subsidence zone lake is complex. Preliminary modelling by Piteau Associates (2018) indicates that concentrations of Fe, Mn, Cu and Al in the subsidence zone lake would exceed water quality objectives at year 50 (Table 6.1). Given this uncertainty, it has been assumed that discharge of water from the subsidence zone lake may require treatment to meet regulatory water quality criteria at the agreed compliance point. Modelling of final pit lake water quality and engineering solutions will be progressively improved as actual data is accumulated during operations. This will help determine the likely period over which water treatment would be required.

Table 6.1: Model simulation of subsidence zone lake water quality during progressive filling to the onset of steady-state discharge, assuming prior cave zone inundation in accordance with each of Scenarios 1, 2 and 3 (Piteau, 2018)

Parameter	Unit	Scenario 1 (Passive filling)			Scenario 2 (Pumped filling)			Scenario 3 (Pumped filling with addition of lime)			Environment (Water Quality Criteria) Regulation 2002
	Year	**1**	**10**	**50**	**1**	**10**	**50**	**1**	**10**	**50**	
Lake volume	Mm^3	0.028	0.60	3.2	0.028	0.60	3.2	0.028	0.60	3.2	
pH	SU	**4.2**	**4.9**	**5.2**	**4.4**	**4.9**	**5.2**	**6.2**	**5.7**	**5.5**	No alteration to natural pH
SO_4	mg/L	**1,419**	**1,015**	245	**1,247**	**970**	245	**1120**	**960**	240	400
Al	mg/L	20.02	16.1	1.8	8.7	6.2	0.9	0.8	1.1	1.6	-
As	mg/L	0.0009	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.05
Ca	mg/L	329	231	84	310	207	82	442	290	246	-
Mg	mg/L	30.3	27	23	24	21	18	37.4	29.2	21.8	-
Cd	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01
Cr	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.05
Co	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	Limit of detectability
Cu	mg/L	**42**	**7.0**	**2.2**	**29**	**6.2**	**1.4**	0.4	0.2	0.2	1.0
Fe	mg/L	**109**	**7.4**	**6.6**	**49**	**6.1**	**5.8**	**21.5**	**3.5**	**2.9**	1.0
Mn	mg/L	**17.3**	**13.2**	**6.4**	**12.1**	**9.4**	**8.8**	**19.3**	**12.7**	**3.2**	0.5
Zn	mg/L	**32.6**	**11.6**	**7.1**	**27.2**	**8.5**	**7.3**	3.3	3.1	1.7	5.0

6.6.3.3. Prevention and/or management of human access to the block cave subsidence zone

The subsidence zone will be geotechnically unstable and the walls will be subject to sudden and unpredictable slope failures. As such, the inside of the subsidence zone will be fundamentally unsafe for human access and will pose a long-term human safety risk.

Prevention and/or management of human access to the subsidence zone during the post closure period will require extensive consultation with the host communities, mine safety regulators and the company.

6.6.4. Proposed Closure Actions

The WGJV proposes the following conceptual closure actions:

- Accelerate the flooding of the block caves and filling of the subsidence zone lake at a nominal rate of 500 L/s.
- Add hydrated lime (nominally 3g/L) to Watut River water that will be discharged into the block cave and subsidence zone lake to increase pH levels and reduce dissolved metal levels.
- Construct, if necessary, controlled points to regulate discharge. These will most likely be through natural spring(s) and a lake decant.
- Identify an appropriate level of water treatment (assumed to be required) to meet regulatory water quality criteria for subsidence zone lake discharges and groundwater springs at a compliance point to be agreed and estimate the expected duration of any water treatment during the post closure period.
- A lime dosing plant may be required once the subsidence zone lake reaches surface level and begins to discharge after about 35 years.
- Install signage and fencing to alert people of the dangers associated with the subsidence zone and inhibit access, subject to the outcome of the extensive consultation that is planned between the host communities, mine safety regulators and the company.

6.7. Domain 3 – Waste Rock Dumps and Ore Stockpile Pads

6.7.1. Description

6.7.1.1. Waste Rock Dumps

The waste rock dumps are proposed to be built in the Boganchong Creek valley below the Watut decline portals as an extension of the portal terrace and serve as the disposal site for waste rock generated from the development of the Watut declines. A second waste rock dump, the Miapilli Waste Rock Dump, will be built for waste rock excavated from the Nambonga Decline. Geochemically, two classes of waste rock are expected to be produced from the construction of both declines (SRK, 2018):

- NAF material, which is expected to remain neutral in pH
- PAF material, which will have a risk of acid generation and metal leaching

The PAF material will be stored in cells within the waste rock dumps and encapsulated by a design cover to exclude the ingress of water and oxygen and, to the maximum practicable extent, prevent AMD. As such, the waste rock dump will be designed and constructed for closure.

6.7.1.2. Ore Stockpile Pads

Ore excavated during the initial development of BC44 will be stored on the coarse ore stockpile and a start-up ore stockpile, both located next to the process plant terrace, until the Watut Process Plant has been built and commissioned. The ore conveyor emerging at the Watut decline portals will continue overland to discharge crushed ore onto the coarse ore stockpile for processing. The start-up ore stockpile will be processed during operations.

During operations, seepage and surface runoff from all ore stockpiles will be collected, monitored and treated as required.

WGJV proposes to reclaim and process all stockpiled ore before the end of the Project.

6.7.2. Closure Objectives

The closure objectives for management of the waste rock dumps and ore stockpile pads are to:

- Minimise the potential for AMD generation or discharge to the surrounding environment
- Manage the waste rock dumps and ore stockpile pads to become self-sustaining, stable landforms post-closure
- Minimise the potential for significant erosion or release of fugitive sediment from areas disturbed during the life of the project to the downstream drainage

6.7.3. Closure Issues

Steep natural topography in the region of the waste rock dumps will introduce high velocity surface water flows that will require management to avoid potential erosion or sediment mobilisation, and achieve self-sustaining landforms.

The waste rock dumps are designed to be structurally and geochemically stable at mine closure, with all PAF material encapsulated and any AMD generation addressed through remediation measures during operations.

6.7.4. Proposed Closure Actions

The WGJV proposes the following conceptual closure actions to minimise the potential for AMD generation, control surface water velocity and minimise erosion and sediment mobilisation:

- Process all remaining stockpiled ore
- Rip and rehabilitate the coarse ore stockpile pad to encourage regrowth of native vegetation
- Place a final cover on the waste rock dumps incorporating a growth medium and a barrier system for limiting oxygen ingress
- Install rip rap (or rock armour) protection in discharge areas to control erosion and avoid landform instabilities
- Install cut-off drains to divert clean water around the waste rock dumps, if required

6.8. Domain 4 – Borrow Pits, Quarries and River Gravel Extraction Sites

6.8.1. Description

Hard rock is proposed to be extracted from the Northern Access Road Borrow Pit, Migiki Borrow Pit and Humphries Borrow Pit (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 aggregate source 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, but may also come from other borrow pits and quarries.

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. The quarry at Mt Beamena will include exposed faces with 6m to 8m bench heights and 4m to 6m bench widths.

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 construction of the Infrastructure Corridor, 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.

6.8.2. Closure Objectives

The closure objectives for management of the borrow pits, quarries and river gravel extraction are to:

- Minimise the potential for ongoing erosion or release of sediment to the surrounding environment
- Make the borrow pits and Mt Beamena Quarry safe, self-sustaining and stable post-closure landforms

6.8.3. Closure Issues

There is the potential for sediment to be mobilised from disturbed surfaces and discharged to local watercourses. The river gravel extraction sites could also be susceptible to ongoing turbidity as a result of the disturbance. The steep and potentially unstable excavations of borrow pits and quarries may also pose a safety risk if accessed by unauthorised personnel.

6.8.4. Proposed Closure Actions

The WGJV proposes the following conceptual closure actions:

- Reprofile final borrow pits and quarries to be stable and self-draining landforms
- Rip and rehabilitate borrow pit and quarry surfaces, where possible, to encourage regrowth of native vegetation
- Construct access-limiting bunds and install signage to alert people to the dangers and inhibit access
- Stabilise river gravel extraction sites and remove constructed levees to allow natural flow paths to resume

6.9. Domain 5 – Mine Area Infrastructure and Industrial Areas

6.9.1. Description

The Mine Area will include an array of assets and infrastructure that are typical of an operational copper-gold mine. Specific infrastructure within the Mine Area includes:

- Watut Process Plant
- Office accommodation and crib rooms for administration, engineering, laboratories and other support
- Accommodation facilities
- Water treatment plants
- Waste management facility
- Plant maintenance facilities including vehicle workshops
- Power generation facilities
- Fuel storage facilities
- Explosives magazines

Other infrastructure in the Mine Area includes fixed assets such as haul roads, access roads and miscellaneous hardstand/laydown areas.

6.9.2. Closure Objectives

The closure objectives for management of Mine Area infrastructure and industrial areas are to:

- Prevent contamination to the surrounding environment through the safe removal of hazardous and contaminated materials
- Appropriately decommission and demolish all assets and infrastructure
- Transfer or resell infrastructure or assets to third parties for continuing use, where possible

6.9.3. Closure Issues

Incorrect disposal of potentially hazardous materials may cause pollution, health and social concerns for the surrounding communities. Potentially hazardous materials include putrescible waste, unused hydrocarbons and process chemicals.

6.9.4. Proposed Closure Actions

The WGJV proposes the following conceptual closure actions:

Hazardous or contaminated materials

- Undertake a contaminated lands assessment during the operational life of the mine as needed and immediately following the cessation of mining and prior to the commencement of decommissioning to identify any contaminated soils or material requiring special handling.
- Excavate ground contaminated by hydrocarbons or other hazardous chemicals and remediate the land.
- Remove hazardous or contaminated materials (e.g. hydrocarbon contaminated soils, waste or unused process chemicals) for remediation or secure disposal or alternatively seek approval to develop an engineered secure disposal site on the mine lease.

Non-hazardous waste

- Remove salvageable materials off-site for transfer or resale
- Bury non-salvageable waste material within a suitable on-site landfill
- Cover landfills with low-permeability material
- Revegetate landfill with appropriate species that will not degrade the integrity of the cover, such as grasses

Assets and infrastructure

- Safely decommission contaminated infrastructure (e.g. bulk fuel storage facility, power generation facilities), where this infrastructure is deemed not to be transferred to local stakeholders
- Remove any remaining explosive materials from the explosives magazine and safely transport off-site for resale
- Demolish remaining structures and buildings, including fracturing concrete foundations and removing to an appropriate depth
- Pump, flush, and cap all non-hydrocarbon sub-surface pipelines (e.g., sewerage infrastructure) and leave *in situ*
- Complete final contour profiling, ripping and rehabilitation of decommissioned and cleared surfaces to encourage regrowth of native vegetation
- Remove all mobile equipment (including power generators) off-site for transfer or resale

6.10. Domain 6 – Sediment Control and Other Water Management Infrastructure

6.10.1. Description

This domain includes all drainage, sediment control and other water management infrastructure established to manage contact-runoff and stormwater from the site, or divert non-contact runoff around the site.

6.10.2. Closure Objectives

The closure objectives for management of sediment control and associated infrastructure are to:

- Minimise the potential for significant ongoing erosion or release of sediment to surface water
- Drainage systems be self-sustaining

6.10.3. Closure Issues

The key closure consideration for this domain is for drainage and flood protection infrastructure remaining at closure to safely convey extreme flow events without significant erosion or loss of integrity of the drainage system itself or of the assets that the drainage system is designed to protect, such as waste rock dumps.

Drainage channels serving critical infrastructure remaining at closure will be designed and constructed to accommodate the Probably Maximum Flood (PMF) event. The drainage layout will be designed to minimise the disturbance area, while maintaining the minimum possible slopes to control water velocity and minimise erosion. A basin outlet will be included at the discharge of each spillway to reduce the velocity of the water downstream preventing erosion. Stilling basins will consist of a trapezoidal-shaped pond lined with a gabion mattress (or equivalent). Rip rap (or rock armour) protection for the discharge areas will be considered to control erosion.

6.10.4. Proposed Closure Actions

The WGJV proposes the following conceptual closure actions:

- Reinstate original drainage lines, where possible, or create drainage that affords self-sustaining drainage systems around disturbance areas which:
  - Promote surface runoff from landforms
  - Divert clean stormwater around potential sources of contamination
  - Intercept and direct toe seepage from waste rock dumps and contaminated surface runoff to purpose-built ponds to attenuate contaminants and sediment prior to passive discharge
- Remove or backfill other water retaining structures used during operations that are not required to divert stormwater or collect runoff post-closure

6.11. Domain 7 – Linear Infrastructure

6.11.1. Description

Outside of the Mine Area, linear infrastructure will be located within the Infrastructure Corridor. The Infrastructure Corridor will host a concentrate pipeline, fuel pipeline and terrestrial tailings pipeline from the Mine Area to the Coastal Area. The Mine Access Road and Northern Access Road will also be located in the Infrastructure Corridor between the Mine Area and the Highlands Highway, near Zifasing.

6.11.2. Closure Objectives

The closure objective for management of linear infrastructure is to decommission linear infrastructure to an agreed standard and leave it in a safe form post-closure.

6.11.3. Closure Issues

Linear infrastructure within the Infrastructure Corridor is not expected to pose contamination or safety risks post-closure.

The Northern Access Road may be left in place for community use following closure, should the State of PNG accept responsibility for this infrastructure, and negotiations would therefore need to be undertaken.

6.11.4. Proposed Closure Actions

The WGJV proposes the following conceptual closure actions:

- Flush the pipelines to remove residue material
- Test for contamination from potential leakage at selected points along the pipeline routes (noting that proposed monitoring and maintenance methods during operation should help to prevent or detect leaks if they occur)
- Decommission and remove above-ground sections of the pipeline and seal the ends of the underground pipeline to remain in situ
- Engage relevant stakeholders to negotiate potential relinquishment of liability for Northern Access Road

6.12. Domain 8 – Port Facilities Area, Outfall Area and Tailings Footprint

6.12.1. Description

Deep sea tailings placement is the preferred option for tailings management from the commencement of operations until closure. Proposed infrastructure comprises:

- Tailings pump station located at the process plant terrace in the Mine Area (part of Domain 5)
- Terrestrial tailings pipeline to transport tailings slurry from the tailings pump station to the Outfall System in the Outfall Area (part of Domain 7)
- Outfall System comprising:
  - A mix/de-aeration tank located in a dry moat set back from the shore
  - A choke station including piping and valves
  - Two DSTP outfall pipelines constructed along the seafloor perpendicular to the coastline, with a length of approximately 1.1km to an outfall depth of approximately 200m
  - Two seawater intake pipelines approximately 315m long and extending to 60m in depth to supply water to the mix/de-aeration tank
- Associated facility buildings and generators, diesel storage, laydown and storage areas, and parking and turnaround areas

The Wafi-Golpu tailings solids are predicted to be fine grained and mostly classified as clays and silts. Tailings solids will be transported via slurry pipeline from the mine area to the coast. Prior to discharge at the DSTP outfall, the tailings slurry will enter a mix/de-aeration tank where it will be diluted with seawater. The tailings slurry will then be discharged at the proposed DSTP outfall at a depth of approximately 200m, located 800m west of the Busu River mouth on the steeply sloping north wall of the Markham Canyon. The depositional footprint for tailings solids has been predicted for the total mine life of 27 years.

The Port Facilities Area within the port of Lae will include concentrate filtration, handling, storage and ship loading, storage of IFO at the Lae bulk fuel storage facility.

6.12.2. Closure Objectives

The closure objective for management of Outfall and Port Facilities Area infrastructure is to:

- Decommission Project infrastructure within the Outfall and Port Facilities Area such that another port user can occupy, use and assume responsibility for the area.

6.12.3. Closure Issues

Infrastructure at the Port Facilities Area and Outfall Area is not expected to pose contamination or safety risks post-closure.

Numerical modelling has simulated the deposition of tailings combined with natural terrigenous sediment over the mine life of 27 years (27 years was originally chosen for the purposes of modelling, noting the projected mine life was subsequently projected to be 28 years). The simulated depositional footprint reveals that the thickest predicted deposits of tailings solids (more than 10m thick) occur between the DSTP outfall and the bottom of the north wall of the Markham Canyon. During the operational phase, deposited tailings solids on the canyon floor will have been eroded and transported through the canyon and redeposited mostly in thin deposits on the canyon floor at water depths of between 1,500m and 2,500m.

The principal stressors on deep-water pelagic ecology during DSTP operation relate mainly to changes in water quality. These include increased tailings suspended solids concentrations and associated turbidity, increased concentrations of trace metals in tailings liquor potential for trace metal bioaccumulation within marine pelagic organisms and potential for biomagnification in the pelagic food web. The potential stressors arising from the proposed DSTP operation on the deep-slope and seafloor benthic habitats and biological communities (benthic ecology) relate to the loss and degradation of benthic habitat due to tailings deposition and potential for bioaccumulation or biomagnification of trace metals in the benthic food web.

Post closure of the mine, natural sedimentation from terrigenous sediment discharged from rivers and the episodic but frequent mass movement events in the Markham Canyon will continue to occur and are expected to eventually bury the deposits of tailing solids. Burial is predicted to occur slowly (<1mm per year) in deep water but quickly (up to about 500mm per year) on the north wall of the canyon between 300 and 400m water depth.

6.12.4. Proposed Closure Actions

The WGJV proposes the following conceptual closure actions:

- Flush the DSTP outfall pipelines with seawater to remove any residual tailings slurry
- Decommission and remove the mix/de-aeration tank to a depth of 2m below surface and transport offsite for resale, recycling or disposal to a suitable landfill (some components such as foundations will remain in situ)
- Disconnect the seawater intake and DSTP outfall pipelines at shallow depth, with the deeper sections remaining in situ
- Decommission and partially demolish the Port Facilities Area as necessary to be adapted for future user to undertake continued use
- Map the final area of tailing deposition and monitor its coverage by natural sedimentation and recolonisation by benthic fauna by conducting follow-up surveys at five years post-closure and ten years post-closure.

6.13. Socioeconomics

The approach to closure is based on a recognition that the direct benefits of the Project (employment, incomes, skill development, royalty flows, supply contracts) will significantly reduce at closure (after the end of the operating period), and planning will therefore be necessary to both communicate and facilitate this transition. Post-closure monitoring, surveillance and maintenance activities will continue to provide limited direct benefits for a finite period.

Throughout the life of the mine and in advance of closure, the WGJV will work in partnership with government and other stakeholders on the implementation of sustainable programs that will facilitate post-closure livelihoods. This includes local and regional economic development programs. Through regular consultation processes, Project-affected communities will be informed of the necessity to transition to other monetary or subsistence livelihoods towards the end of mine life, leading up to closure and relinquishment of the Project special mining lease.

This section considers the regional economic sector and the Project affected communities. At this conceptual stage of closure planning, the regional economy is conceptualised as being significantly influenced by the:

- Project workforce, through employment and skills development, income taxation, multiplier effects
- Project supply chain participants, local procurement and contracting for goods and services
- Government revenue, derived from mine production through company tax, royalties and dividend payments

The regional economy is also influenced by the increased revenue received by Project-affected communities during the mine life, including royalties.

Discussion of Project-affected communities considers the effects of mine closure upon the human capital and physical assets of these communities, which also has indirect consequences for the regional economy.

Closure considerations for these components are described below.

6.13.1. Regional Economy

6.13.1.1. 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. As local communities are prioritised in terms of employment preference, it is expected that, during operations, formal employment as a contributor to household income within local communities will substantially increase compared to pre-Project conditions. Project closure will impact on the workers given the significant reduction in available positions during the decommissioning period and post-closure.

6.13.1.1.1. Closure Objectives

The primary objective of workforce closure planning will be to have a contemporary understanding of local demand for skilled workers, and to assist the WGJV workforce prepare for, and apply for, appropriate job opportunities that may be available locally, within Morobe Province or nationally.

6.13.1.1.2. Closure Issues

Potential closure issues include the following:

- Unrealistic expectations – While workers will be informed well before the final stages of mining operations, clear communication will be required so that workers understand re-deployment is a possibility but not guaranteed, and workers themselves are responsible for seeking alternative employment post-closure.
- Retrenchment – Clear communication regarding retrenchment arrangements and timing for the workforce may assist workers when planning their futures post-closure.
- Premature departure of staff – Staff with key skills and operational experience and knowledge of local conditions will need to be retained to manage aspects of the closure process. A detailed closure plan completed prior to closure will identify key roles and plan incentives for retention.
- Alternative employment – An understanding of the National and Provincial re-skilling programs available to workers may assist post-closure planning for staff.

- Access to services – Workers will be made aware of the social and employment services available from National and Provincial programs during and post-closure that may assist them.

6.13.1.1.3. Closure Actions

The WGJV proposes the following conceptual closure actions: to undertake a skills assessment of the Project-affected community employees, i.e., those identified as Tier 1 and Tier 2 communities, to identify transferrable skills for alternate employment, and to provide this feedback along with a list of existing National and Provincial training opportunities for employees to take up at their own initiative.

6.13.1.2. Supply Chain Participants

Service providers and suppliers to a project of this scale will range from large to small, from international to national and local. While any Lae-based suppliers will be impacted by the closure of the Project, it is also likely there will be a small number of local providers and onsite contractors who provide jobs for unskilled and semi-skilled workers, which will also be impacted by closure.

6.13.1.2.1. Closure Objectives

The primary objective of supply chain closure planning will be to facilitate the consideration of mine closure effects into individual supply-chain participant's business plans to assist with planning for on-going business viability. This will be achieved through regular and transparent consultation with individual supply-chain participants well in advance of entering the closure phase for the Project.

6.13.1.2.2. Closure Issues

Closure issues could include:

- Misinformation about, or inadequate understanding of, the closure plan causing missed opportunities for service providers and contractors to prepare adequately for closure and to position themselves for continuity of work, if possible, during the closure phase.
- Development of short-term employment (i.e., the duration of closure works), due to the likelihood that some closure activities will require a different skillset than normal mining operations. This requirement for specific skills may continue post-closure, with monitoring, surveillance, maintenance and management activities, including post-closure water treatment, proposed to be undertaken based on current modelling of post-closure water quality in the subsidence zone.
- Provision for on-going monitoring and maintenance of remaining infrastructure prior to full decommissioning. This maintenance may require the limited engagement of new service providers and specialist contractors and will include roads for access to rehabilitation and environmental monitoring during closure.

6.13.1.2.3. Closure Actions

The WGJV proposes the following conceptual closure action:

- Clear and timely disclosure of the closure plan to allow businesses and contractors to prepare themselves adequately for closure.

6.13.1.3. Government Revenue

Over the life of the Project the regional economy will benefit from revenue received by the Provincial Government through the distribution of royalties and the Special Support Grant Program from the National Government. Spending programs and grants are expected to be targeted in the mining affected areas, and in the broader provincial economy, to support development through the provision of infrastructure and other economic stimulation such as the development of commercial agriculture and other local industries.

6.13.1.3.1. Closure Objectives

The primary objective of closure planning in relation to government revenue will be to encourage the Morobe Provincial Government and National Government to give early consideration to the fiscal implications of mine closure in its future development plans.

6.13.1.3.2. Closure Issues

Closure issues could include:

- Lack of alternative sources of funding for governments to maintain existing levels of service in absence of the revenue received from the Project
- Ongoing maintenance of Project-supplied infrastructure

6.13.1.3.3. Closure Actions

The Wafi-Golpu Joint Venture proposes the following conceptual closure actions:

- Engage with the government to undertake negotiation and planning for eventual closure of the mine
- Assess financial risks and the capacity of government and key stakeholders to maintain infrastructure to appropriate levels

6.13.2. Project-affected Communities

The human capital of Project-affected communities will change over the life of the Project. Employment and training through the duration of operations may increase the financial base and skills of those employed by the Project (and suppliers).

6.13.2.1. Closure Objectives

A key aspect of mine closure planning is to promote sustainable improvements to economic and social well-being and to minimise the reliance on the Project by the local community. The aim will be to leave behind sustainable economic benefits with flow-on effects including improved health and educational services.

The WGJV's strategic community investment will be designed to align with the development priorities of the government. The community development framework will endeavour to increase capability and capacity while the Project is in operation becoming self-sustaining following mine closure.

6.13.2.2. Closure Issues

Closure issues could include:

- The level of financial management and planning skills within local communities
- Uncertain governance arrangements for the on-going stewardship of any financial instruments (such as trust funds) established for future generations

- Establishing community consensus around strategic options for the development and management of assets to support sustainable livelihoods
- Maximising post-closure employment and business opportunities, related to on-going environmental management and monitoring, for local individuals and businesses

6.13.2.3. Closure Actions

The WGJV proposes the following conceptual closure actions:

- Ongoing consultation and engagement with Project-affected communities on personal financial management and life planning skills.
- Encouraging training and instruction for trustees and/or responsible persons for any trust funds established for future generations to assist the affected communities to continue to undertake good governance and stewardship in the post closure period.
- Ongoing consultation and engagement with Project-affected communities on closure objectives and outcomes, in particular in the preceding five years leading up to decommissioning.
- Negotiation with service providers to maximise post-closure employment and business opportunities, related to on-going environmental management and monitoring, for local individuals and businesses.

6.14. Areas for Further Detailed Investigation

This Conceptual Closure and Rehabilitation Plan provides a planning framework for mine closure with the goal of outlining conceptual closure actions that WGJV proposes to undertake during decommissioning and the post-closure period. These proposed actions will be refined based on experience and knowledge gained during construction and operation, consultation with Project-affected communities and other key stakeholders, as well as a number of targeted closure investigations to further refine and develop closure actions.

Areas for further detailed investigation include:

- Subsidence zone lake, specifically:
  - Further refinement of modelling (physical and chemical) to determine the likely water chemistry of the subsidence zone lake over time. This would include simulation of the effect of PAF materials that may occur within the exposed walls of the subsidence zone and water quality of the lake
  - Refinement of the prediction of the discharge point(s) from the subsidence zone lake
  - Assessment of the feasibility of water treatment options that may be required
  - Investigate methods to limit acid generation in the subsidence zone including the optimisation of techniques to apply lime to the subsidence zone lake (such as direct addition or via aerial spraying) or additional pumping to further accelerate filling of the subsidence zone lake
  - Case study assessment of other block caves and subsidence lakes to determine the extent to which stratification (thermal and chemical) occurs and sensitivity modelling runs to determine implications for water quality and management
- Revegetation trials using a range of species
- Feasibility of infrastructure handover
- Refinement of governance arrangements for the on-going stewardship of any financial instruments (such as trust funds)

- Skills assessment of Project-affected community employees

7. UNPLANNED CLOSURE

There is the potential for the operations of any mining project to be temporarily suspended prior to the planned closure date. Temporary closure could be caused by a range of unexpected causes. If operations were suspended temporarily, then the mine may (depending on the duration and circumstances) be placed under care-and-maintenance so as to be able to restart in a timely and efficient manner at the later date; however, a temporary suspension could also (depending on the duration and circumstances) possibly develop into a permanent closure. Potential causes of closure need to be identified and contingency plans developed.

7.1. Mine Openings and Watut Process Plant

The underground mine, Watut Process Plant and associated operational facilities are generally not amenable to preparation for closure during early shutdown periods. The closure strategy will need to be tailored to the state of mine development and infrastructure present at the time. However, the closure strategies described in Section 6 will remain relevant, and require adjustment to meet the specific requirements.

In the event of a temporary suspension under a care and maintenance program, the mine workings will require ongoing dewatering and any necessary treatment of the water to meet discharge criteria. Maintaining the mine ventilation system to allow access to sump pumps for ongoing dewatering will also be required.

7.2. Project-affected Communities and Regional Economy

To minimise the nature and extent of unplanned closure impacts on Project-affected communities and the regional economy, the Project will endeavour to:

- Maximise the use of local contractors, and engagement of local workers, for care-and-maintenance activities
- Maintain infrastructure to the extent practicable, such as roads, supporting mine site and regional access
- Maintain regular communication with government and Project-affected communities with regard to the expected duration of any closure and the development of conditions supporting re-opening
- Discuss the reasons for, and the expected duration of, unplanned closure with governments and Project-affected communities

7.3. Waste Rock Dumps, Borrow Pits and Drilling Pads

As discussed in Section 6.4, some areas such as the worked out borrow pits, drilling pads and the waste rock dumps will be progressively rehabilitated to reduce risks associated with unplanned closure. Drainage lines in the vicinity of these structures will be aligned to meet closure requirements during operations. Potentially acid-forming material in the waste rock dumps will be progressively encapsulated with a design cover to minimise AMD and with dump batters graded to final shape and revegetated.

7.4. Infrastructure and Access

During any care-and-maintenance periods, all non-essential infrastructure and the Fere Accommodation Facility will be secured (i.e., locked to prevent theft and vandalism). Similarly, the process plant equipment will be drained and placed into care and maintenance, and buildings secured. Power supply will be reduced to support only essential requirements (e.g., water pumping and treatment, mine ventilation, etc.). Site access will be restricted to only those areas that provide essential services.

7.5. Monitoring Programs

Monitoring programs established during operations, such as those used for surface water and groundwater flows and quality, will be suitable for use with some modification, in the event of unplanned temporary closure.

8. POST-CLOSURE MONITORING

Successful closure requires certain closure criteria (to be refined as the conceptual mine plan is progressively updated in consultation with the government and in consideration of stakeholder expectations) are met. A key part of this process is a robust monitoring system based on closure criteria and indicators that provide evidence and assurance that rehabilitation has been successful (as defined by the outcomes agreed with the government). Monitoring intensity is expected to reduce over time with successful implementation of mine closure activities and as closure criteria are achieved. In the event that monitoring indicates a failure to progress toward agreed closure objectives, a re-appraisal of the closure strategy and remedial works will be undertaken.

Procedures will be developed for monitoring the performance of constructed landforms such as the waste rock dumps, plugged decline portals and other disturbed areas for erosion, stability, revegetation success and other factors.

The primary objectives of the environmental and social post-closure monitoring program will be:

- Compliance with relevant conditions in the *Mining Act 1992* licenses and environment permits
- Compliance with Project standards
- Assess environmental and social impacts of Project activities and determine if additional management measures are required
- Determine if the desired outcomes have been achieved
- Determine the need for remedial action where required

A summary of the indicative elements of the mine rehabilitation and closure monitoring program is provided below. This program will be refined during operations as closure planning progresses. Potential locations for monitoring will be developed based on information obtained during the operations monitoring program. Performance targets will be progressive refined and become more specific once closure criteria have been agreed.

Monitoring will include:

- Engineering inspections to monitor operating to design specifications of the:
  - Structural integrity of portals and ventilation shaft
  - Surface water control and collection infrastructure
  - Landfill cap and gas management system
  - Water treatment infrastructure
- Surface water monitoring at:
  - Discharge locations from subsidence zone lake and waste rock dumps to monitor consequences of predicted AMD generation
  - Upstream and downstream points downstream of operational areas

- Groundwater monitoring:
  - Water quality at monitoring bores
  - Groundwater levels in nominated monitoring bores near subsidence zone
- Assessment of erosion and rate of accumulation of sediments in designated ponds
- Chemistry and benthic biology of ocean floor sediments in the predicted tailings deposition zone to compare with pre-mining (baseline) and reference site conditions to determine the trajectory of change over time
- Biological monitoring of:
  - Species diversity and vegetation cover of rehabilitated areas
  - Abundance of invasive species
- Socio-economic survey to assess the effectiveness and outcomes of social programs

Construction of final closure landforms will be followed by a period of monitoring prior to relinquishment of the site. During this time the WGJV will remain responsible for ongoing management of the site including maintenance of roads, maintenance of equipment and potentially repairs to any failed landforms. A detailed maintenance plan will be developed in the year prior to closure of the site however it is expected to include the elements outlined in the section above.

It is envisaged that a small workforce will be employed to conduct maintenance and monitoring activities. The WGJV will develop an appropriate funding and governance structure for post-closure maintenance and monitoring.

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